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# WIRELESS TELEGRAPHY AND TELEPHONY.

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THIS paper is a brief review of the art commonly known as "wireless telegraphy"; and deals with only one branch of the general subject, that is, with wireless telegraphy and wireless telephony which employ as the energy transmitted through space from the sending to the receiving station what are commonly known as "Hertzian oscillations" or "Hertzian waves," or "electro-magnetic waves," all being synonymous.

There are other systems of wireless telegraphy and telephony which will not be considered, because, so far as the author knows, they have not come into any extensive commercial or general use; that is, the "earth shunt" and simple "induction" systems.

Had this paper been written ten years ago, it might well have gone into greater detail than will be the case now, because at that time the art was quite restricted as compared with the present time.

Fundamentally, wireless telegraphy and telephony depend upon a wave propagation through the ether, the energy having electric and magnetic components, and with a frequency so high as compared with ordinary alternating currents as to denote the energy as "high-

from any suitable source of electricity, it will discharge through the circuit containing itself and the inductance L. The charge will swing first one way and then the other, back and forth, at high rate, gradually dying out owing to radiation of energy from the circuit and owing to resistance and other losses in the circuit.

The frequency of the oscillations so produced is dependent upon the capacity of the condenser C, the magnitude of the inductance L, and the resistance of the circuit. The resistance of the circuit should be made as low as possible consistent with other requirements; and when below a certain critical value oscillations take place, and when the resistance is made low, it may be disregarded as a factor in the determination of the natural frequency of the circuit.

The natural frequency of the circuit may then be expressed as follows:

$$N = \frac{1}{2\pi\sqrt{LC}}$$

N being the number of complete cycles per second, L the inductance, and C the capacity of the circuit. It is evident that N will be greater as either L or C, or both, is or are smaller. This shows algebraically that for high-frequency work inductances and capacities employed are quite small as compared with those used in ordinary alternating-current commercial work.

The speed or velocity of propagation of the energy of Hertzian or electro-magnetic waves through space is the same as that of light, namely, 186,000 miles per second. Knowing this, and knowing also the frequency, N, the wave length is easily computed from the expression

$$V = N\lambda$$

where V is the velocity of propagation, N the frequency, and $\lambda$ the wave length.

The high-frequency oscillations may be graphically represented as in Fig. 2. Distances measured horizontally represent time, while those measured vertically represent amplitude or intensity. The upper part of the figure illustrates a slightly damped train of waves or oscillations, and are such as may be produced by what is termed a resonator. In the lower half of the figure is shown a train of strongly damped oscillations which die out very quickly. Such oscillations exist in a good radiator, it being characteristic of a resonator or

sustained oscillator that radiation of energy into space may be slight, while in the case of strongly damped oscillations the radiation may be relatively great; or, to put it another way, when radiation is efficient and great, the oscillations are relatively strongly damped.

In wireless telegraphy, particularly in the spark systems, good radiation is desirable, as also is persistency of the oscillations, so that we have opposed conditions to be met. Persistent oscillations make it easier for "tuning" the distant receiving apparatus, while good radiation means that the energy can penetrate to a greater distance.

Coming now to something more concrete, Fig. 3 represents the Hertz oscillator or transmitter.

Heinrich Hertz was the first to profoundly investigate the subject

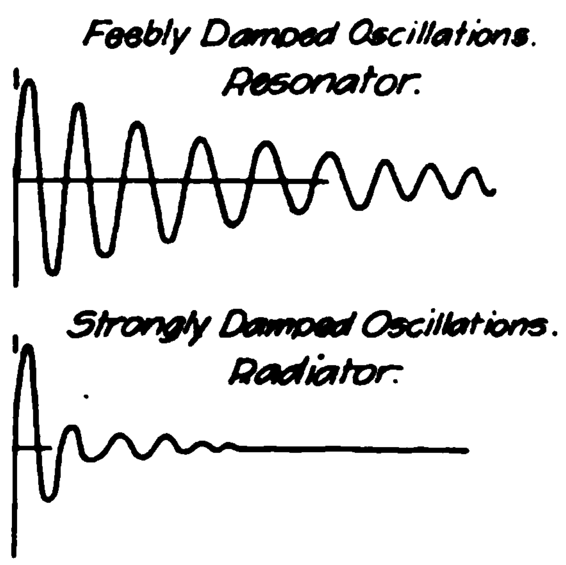


FIG. 2.

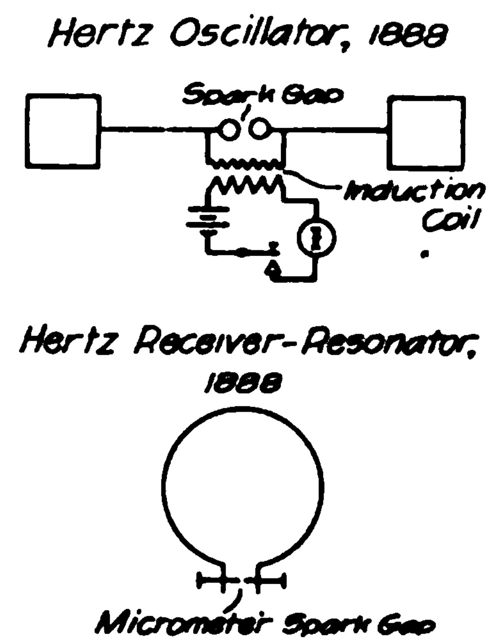


FIG. 3.

of high-frequency electric waves or oscillations. In 1888, or thereabouts, as professor at the University of Bonn, in Germany, he constructed such an oscillator. It consists of two conducting plates, here shown rectangular, each connected to a ball or other spark gap terminal, the balls being separated a short distance to form the spark gap. The secondary winding of an ordinary induction or Ruhmkorff coil has its terminals connected to the spark gap terminals, while in the primary winding of the induction coil is included a battery or other source of energy, suitable interrupter, and a switch or key. The secondary of the coil delivers high-potential current, thus charging one of the capacity areas positively and the other negatively. When their potential rises sufficiently high, a spark leaps across the spark gap, forming an instantaneous circuit closer or bridge over which the electric charge oscillates or vibrates at an extremely high

rate. By opening and closing the switch or key the sparking is stopped or started.

His receiver is shown in the lower portion of the figure. It is known as a resonator and consists of a loop of wire having its ends separated by a micrometer spark gap. He chose the product of the capacity and inductance of the loop to conform suitably with the product of the capacity and inductance of the separated plates and their connections in the oscillator, and upon the passage of a spark at the spark gap of the oscillator there was a passage of a minute spark at the micrometer gap of the receiver or resonator.

This was then a complete wireless telegraph apparatus, though in the form shown was not suitable for very long distance work.

Because of the form of the oscillator, having large separated areas connected by a slender conductor, it has been termed the "dumb-bell" oscillator.

So to speak, Hertz set his electric pendulum, the oscillator, into vibration, and his loop or resonator being in electric sympathy with it, tuned to the frequency of his pendulum, his receiver responded efficiently to the frequency of the transmitter and caused the spark at the micrometer gap.

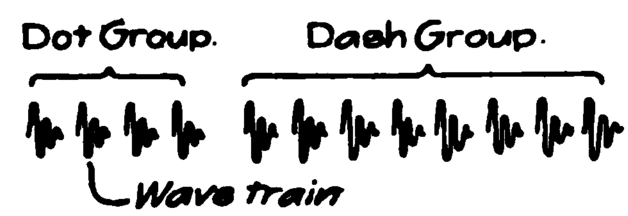

FIG. 4.

For every impulse of high-potential current from the secondary of the induction coil there was a spark at the gap of the oscillator or transmitter, and for each of those sparks there was generated a "train" or "group" of high-frequency oscillations or waves.

This may be illustrated by Fig. 4.

To represent a "dot" in wireless telegraphy a few wave trains or wave groups succeed each other, while for a "dash" a greater number of wave trains or groups succeed each other, this being determined by the length of time the key or switch in the primary of the induction coil is held closed.

Coming now to the original Marconi transmitter, illustrated in Fig. 5, we have in the left-hand view an aërial conductor or antenna, as it is indifferently called, consisting of a wire or conductor extending upward above the earth's surface and having its lower end connected to a spark gap terminal, the other spark gap terminal connected to earth, the secondary of an induction coil connected to the spark gap terminals and the primary including the source of energy, key, and interrupter. You will at once see that this is precisely the Hertz

oscillator of Fig. 3, the aërial conductor or antenna of Fig. 5 representing one of the capacity areas of Hertz's oscillator, while the earth is the other. Here the oscillations are produced in the aërial conductor or antenna and are radiated from it in all directions, as light from a candle. It has been found that where the oscillations are generated in the aërial conductor itself the length of the aërial conductor is equal to one-fourth the length of the wave generated in it. Thus, if the aërial conductor is 150 feet long, the length of the wave generated in it and radiated from it is 600 feet. Such an aërial conductor, having relatively small inductance, is a good radiator, the oscillations being capable of dying out quite rapidly owing to the radiation of energy into the surrounding medium.

In the next to the right-hand view is shown an inductive coupling, the high-frequency oscillations being produced in a circuit including

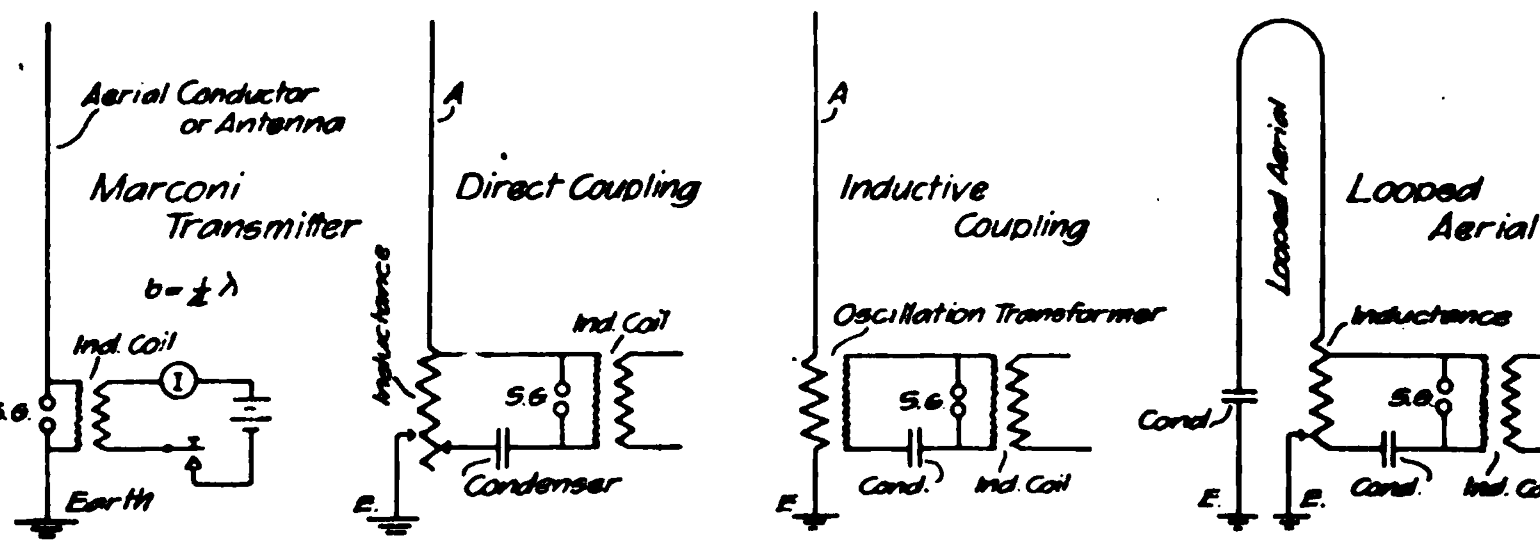


FIG. 5

the spark gap s g, the condenser and the primary of an oscillation transformer, the secondary of the oscillation transformer being connected in series between the aërial conductor and earth. This makes a very good transmitter; the frequency of the radiated energy may be very closely determined and controlled and the oscillations are not generated or produced in the aërial conductor, but are forced thereon through the medium of the oscillation transformer. So that here the antenna does not entirely determine the frequency or wave length of the radiated energy. However, if the oscillation circuit, including the condenser, spark gap, and primary oscillation transformer, has a natural frequency which is relatively low, and the length of the antenna is far below one-quarter of the wave length corresponding to the oscillations in the condenser circuit, the antenna will not be radiating to the best advantage. This condition

of affairs is often met in the matters of contract with the Government where, with a given output of the current generator at the transmitter, a great range in wave lengths radiated is required. To store in the condenser the full output of the generating apparatus the condenser must be relatively large. Yet when the condenser is of relatively great capacity it reduces the frequency and, therefore, increases the wave length of the oscillations in the condenser circuit. And this, in turn, means that a given aërial conductor will be too short to efficiently radiate the low-frequency energy, while at the higher frequencies it would efficiently radiate. And if it be attempted to crowd matters by raising voltage, the antenna delivers a brush discharge, the excess energy which it cannot radiate being so dissipated into the immediately surrounding atmosphere.

In the next to the left-hand figure is shown a direct coupling with a closed oscillation circuit. Here the part of the variable inductance

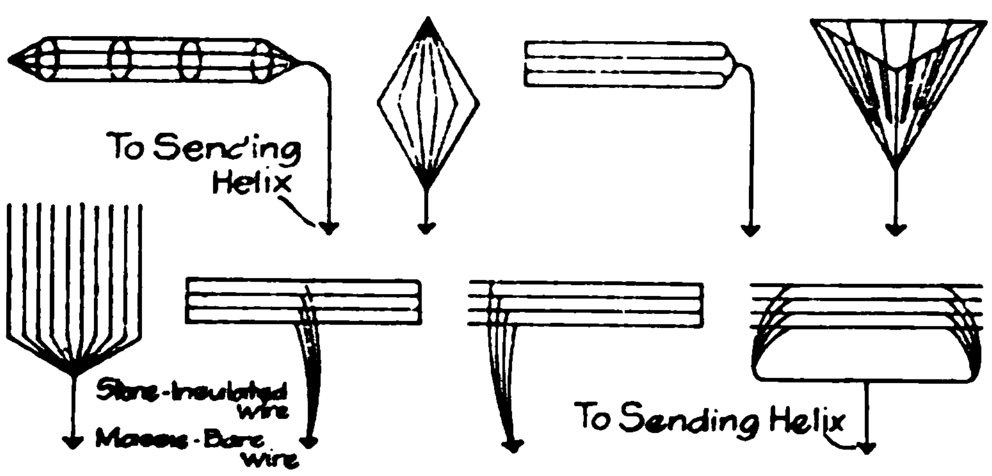


FIG. 6.

connected between the radiating or aërial conductor and earth is also common to the closed oscillation circuit, including the spark gap s g and the condenser. This makes an excellent transmitter, and by adjusting the amounts of inductance in the aërial and in the condenser circuit the aërial path may be brought into tune or resonance with the closed oscillation circuit.

In the right-hand view is shown a looped aërial conductor which is not insulated at the top, but has its top connected to earth. The connection between the condenser or oscillation circuit and the aërial conductor is a direct coupling, as in the next to the left-hand view.

These views of Fig. 5 represent elementally some of the better known and more useful transmitters as used to-day, though the early Marconi transmitter is seldom, if ever, used, except perhaps by amateurs or for very short transmissions.

In Fig. 6 are shown elementally different constructions of aërial

conductors without regard to the form or type of oscillation producer used in connection therewith.

In the upper left-hand corner is shown a wire cage located at the top of the aërial conductor, either horizontally or in any other position, which gives added capacity at the top of the conductor. The next below shows also a multiple arrangement of wires at the top. The one next shows a plurality of wires extending vertically and having a common connection at the bottom to the sending apparatus. The one in the lower right-hand corner shows a plurality of horizontally disposed wires at the top, connected in parallel with each other and connected together at the bottom to the sending apparatus. There is shown also a spread-out antenna of a plurality of wires in diamond shape; and also an inverted three-sided pyramid arrangement. Next below is a plurality of multiple horizontal wires connected together from their centers to sending apparatus. And there is shown a plurality of horizontal wires at the top having several separated connections coming to a common connection downward to the sending apparatus.

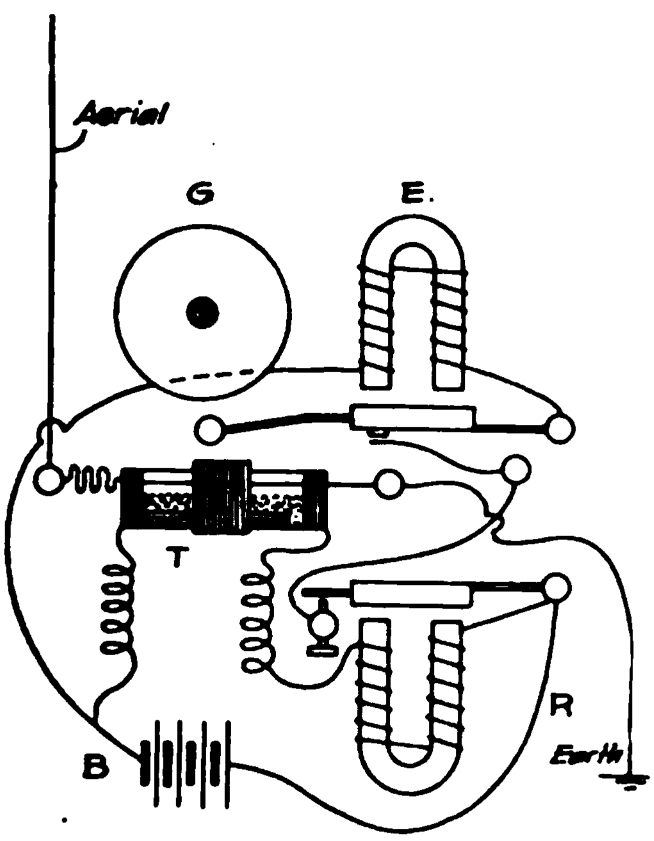

FIG. 7.

While Fig. 6 illustrates numerous forms of spread-out aërials or antennas, it has been found good practice also to have the aërial conductor composed of a plurality of wires which are closely bunched instead of being spread out. With a spread-out arrangement, if the spread is any considerable fraction of the wave length, each conductor sends out its wave, and there results a combination of dephased waves in space, which is a disadvantage in most cases to the receiving apparatus.

Coming now to receiving apparatus, probably the first practical wireless telegraph receiver was devised by Popoff, of the Russian navy, who in 1895 devised the apparatus shown in Fig. 7. This apparatus was devised for recording and predicting lightning storms, some recorded being at such distance that at the location of the recording apparatus it was not otherwise known that a lightning storm existed. The flash of lightning produced became a natural spark gap or natural producer of oscillations, and these oscillations were picked up on an

aërial wire whose lower terminal was connected to one terminal of the filings tube or coherer T, the other terminal being connected to earth. The coherer or filings tube T comprised separated terminals within a glass tube, between and in contact with which was placed a mass of iron or other metal filings. Such a device, as found in 1892 by Branley, was sensitive to electric waves or high-frequency oscillations. The device normally has a very high resistance, but upon high-frequency oscillations traversing the device the filings drop enormously in resistance (the resistance reduction is used to produce the signal) and remain in the condition of low resistance until mechanically shocked, when they again resume the high-resistance state. The action has been explained as one of cohesion, and, therefore, the device has been termed a "coherer." And though detectors or wave-responsive devices coming later in the art did not comprise filings or anything like them, the term "coherer" became for a long period a general one to denote all types of wireless detectors. Popoff connected in series with the filings tube the battery B and the relay R, the relay controlling also a local circuit including the winding of an electric bell magnet E, the hammer being used to strike the tube, to automatically restore the tube to sensitive condition. Popoff's arrangement was, in fact, a perfectly practical wireless telegraph receiver.

Later, Marconi used almost identically this arrangement as his receiving apparatus in connection with the transmitting apparatus shown to the left in Fig. 5.

Coming now to later forms of the receiving apparatus, and such as may be taken as fairly representative of types, without going into great detail, Fig. 8 shows in the left-hand figure a non-tuned receiver having an open aërial conductor, between which and earth is connected a detector comprising carbon filaments resting on steel knife-edges, and in a local circuit is included a telephone and a battery. At each spark at the distant transmitting apparatus a train of waves is radiated into space, and these waves impinge upon the aërial conductor, setting up therein minute high-frequency currents or oscillations which surge up and down in the conductor through the detector or oscillation-sensitive device, causing it to change its condition suddenly, to thereby cause increased or decreased current through the telephone, producing therein a click, such click corresponding with the spark at the distant station. Several clicks coming close together indicate a dot, and a longer series of clicks indicates a

dash. This has been called a non-tuned receiver, though it may be roughly tuned to the transmitting apparatus if the dimensions and disposition of the aërial conductor are similar to those of the aërial conductor of the transmitting apparatus.

In the middle sketch is shown a tuned receiver having an aërial conductor, between which and earth are connected the variable inductance and variable condenser. In shunt to the condenser is connected the detector or sensitive device, and in shunt to it is connected a telephone receiver and battery. To get the receiving apparatus into tune the condenser or inductance, or both, is or are suitably varied.

In the right-hand sketch is shown a looped aërial conductor with

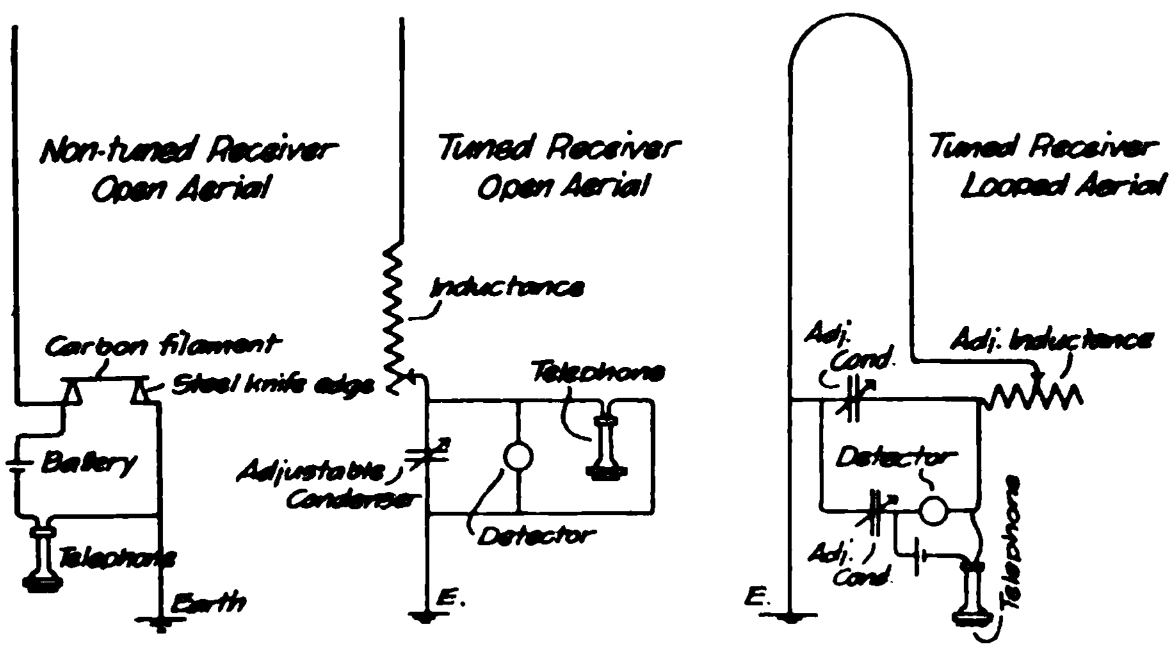


FIG. 8.

tuning apparatus, the latter comprising an adjustable inductance and an adjustable condenser.

An important element of each wireless telegraph set is the detector or sensitive device at the receiving station. A good detector, one which is very sensitive yet rugged, and not likely to get out of order, is an important factor in satisfactory wireless telegraphy and telephony. But even with the best of detectors, if the transmitting apparatus is not of the best form or type, or if the receiving circuits independent of the detector are not of the best form or type, successful communication cannot be had.

In Fig. 9 are illustrated several forms of detectors.

It will be recalled that the filings coherer had to be tapped to restore it to sensitiveness ready to respond to the next train of received waves or oscillations. It was not, therefore, a self-restoring detector or receiver. The receivers or detectors of Fig. 10 are all

self-restoring; that is, immediately after response has been made to a received wave train, it restores itself, or automatically returns to sensitive condition ready to respond to the next train of arriving waves. All the detectors shown in this figure are of the liquid type; that is, they comprise two terminals bridged in one form or another by liquid.

In the upper left-hand corner is shown the Pupin detector of 1899, due to Professor Pupin of Columbia University, who used it to detect Hertzian oscillations, just such oscillations as are used in wireless telegraphy. The action was, as he believed, a rectification of the Hertz waves, more or less complete. The high-frequency alternating currents or Hertzian waves or oscillations were believed to act upon the cell with its adjuncts in such fashion that the oscillations were

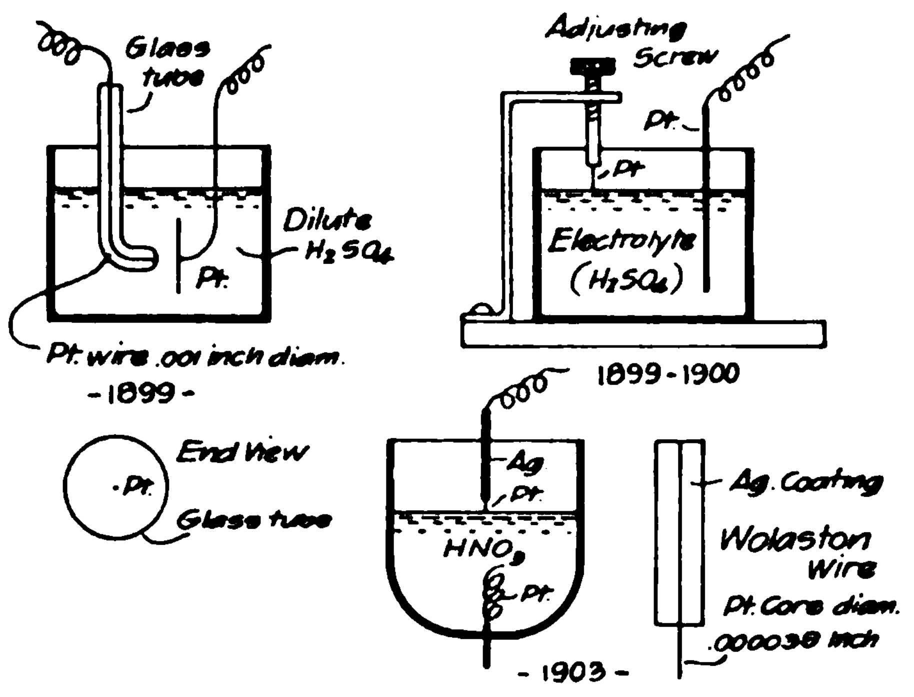


FIG. 9.

more or less rectified. But, whatever the action, the result was that an indicating instrument gave a decided indication at each spark of the transmitter, or, what is the same thing, for each train of waves generated and received. This detector consists of a mass of dilute sulphuric acid in which dips a terminal of platinum, wire or plate. The other terminal is a platinum wire, 1 mil. (0.001 inch) in diameter, sealed in a glass tube, the platinum wire being polished or ground off flush with the end of the glass so that only the cross-sectional area of the end of the glass is exposed to the solution. This small area is separated in the sulphuric acid from the other and larger platinum terminal. This is, indeed, a sensitive detector, and the author has himself successfully employed it in Philadelphia at the wireless telegraph station on the Bellevue-Stratford Hotel; and with-

out any effort at tuning has received distinct and loud messages from New York and Washington. And with crude tuning apparatus, which is necessary with even the best of detectors, it was possible to pick up messages from very much greater distances. Indeed, so far as the author knows, the Pupin detector is about as good, all matters considered, as exists to-day.

The Pupin detector, exactly as shown in the figure, has been used with marked success in the United States navy.

At the upper right-hand corner of Fig. 9 is shown a very similar detector due to Captain Ferrié of the French army. In 1899 and 1900 he successfully used this detector, platinum and platinum in dilute sulphuric acid, in transmitting messages between the different army stations or forts around Paris, as Captain Ferrié himself told

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Fig. 10.

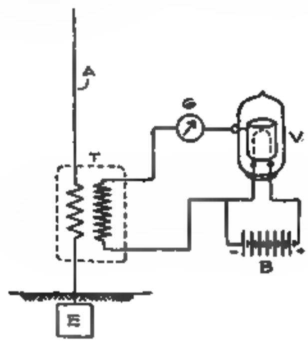



Fig. 11.

me. Like the previous detector, it is self-restoring, and it is, indeed, the same in principle.

Later, in this country, there was evolved the Wollaston wire form, using one large platinum terminal in nitric acid, and as the other terminal the platinum core of a Wollaston wire projecting into the acid. The platinum core is extremely fine, being only about 0.00004 inch in diameter—a microscopic wire. This produces a very sensitive detector, but is not as rugged as the Pupin form, where the wire is inclosed in glass and is not so easily destroyed. The Pupin arrangement is "fool proof," while the Wollaston wire type is much more delicate and probably more sensitive.

In Fig. 10 is shown still another form of self-restoring detector, consisting of the Pupin glass tube, 3, with the small platinum wire, 4, sealed in and ground off flush with the glass. This dips into dilute

sulphuric acid or other cell excitant contained in the jar or vessel, 1, the other element being a plate or bar, 6, of zinc or other metal or conductor other than platinum. This device having dissimilar metals thus constitutes a primary cell, and it is known as the primary cell detector. It is very sensitive and, like the Pupin device, is "fool proof." The telephone is connected directly to the terminals 5 and 7; no local battery is employed.

In Fig. 11 is shown a curious type of detector accredited to Professor Fleming, of England. It is called a "valve tube," and consists of an exhausted bulb, V, similar to an incandescent lamp bulb, in which is a carbon or other filament, shown in dotted lines. Surrounding this is a metallic cylinder, as of platinum. In circuit with the carbon filament is a source of energy, B, to keep it incandescent. The oscillations delivered from the secondary of the oscillation transformer, T, pass through the indicating instrument, G, to the plate in the vicinity of the heated carbon filament; the heated carbon filament forms the other terminal of the detector. This device is said to be a rectifier, causing the high-frequency current waves or oscillations to be rectified to give an indication in the instrument, G, which may be a telephone.

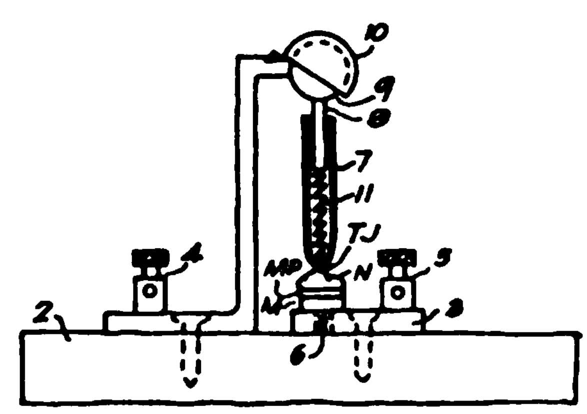


FIG. 12.

A detector resembling the Fleming detector is called the "Audion." Both of these detectors are self-restoring. A carbon filament within an evacuated bulb is kept hot or at incandescence by the source of energy or a battery. The carbon filament forms one terminal of the detector, being connected to earth, while the other terminal within the bulb is of platinum or other suitable material, and connects with the receiving circuit. In the local circuit is a battery and relay, telephone or other instrument. Rectification probably occurs here also. But it is immaterial what the process may be in any detector; the fact is always that the received oscillations produce a change in or by the detector, which change is noted in the telephone and read by the operator. Whether the action of a detector be rectification, resistance change, depolarization, or what not, is a matter of extreme indifference from the commercial and practical standpoint, inasmuch as whichever of these or other processes may occur, the

in the selection and mounting of the crystal an extremely sensitive self-restoring detector is produced.

Indeed, many crystalline substances serve for wireless telegraph detectors. Experimenters are finding out that very many crystalline substances have the property of responding to electrical waves to some degree or other.

In Fig. 14 is represented what the author believes to be one of the best and most sensitive detectors of the present day. This is also due to Mr. Pickard, and is known as the "Pericon" detector. It is self-restoring and requires no local battery, as in the case of the silicon detector. In engagement with a mass of fused zinc oxide, Z,

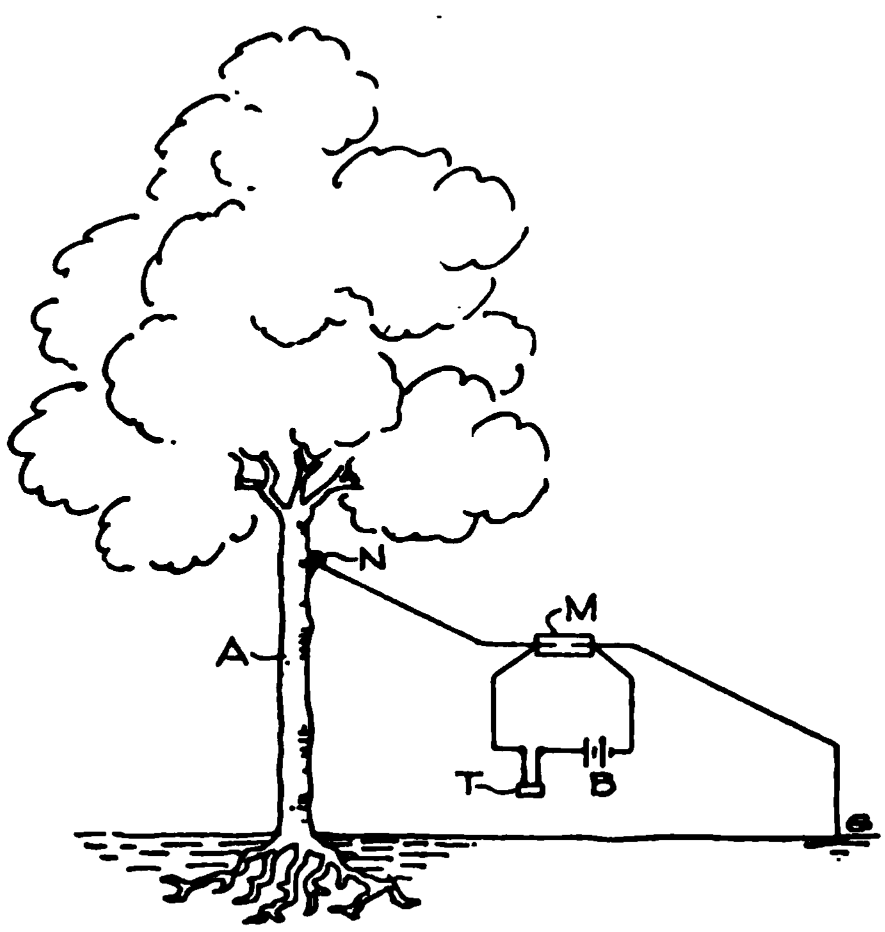



FIG. 15.

is a metallic or other conductor, A. Zinc oxide is fused, preferably in an electric arc, and when cool a piece is fractured to produce a sharp edge or roughened surface for the engagement of the conductor, A, or the natural mineral may be used.

While different types of detectors have been shown, some connected in certain types of receiving circuits or arrangements, it must be understood that different detectors may each be used in various different circuit arrangements and connections. A detector, in general, does not require any particular arrangement of circuits or mode of connection, but some modes of connection are more effective than others.

It may be interesting to know that the usual aërial conductor or

antenna, with its necessary mast or other means of support, is not always required, though it is required for best operation. It has been found, as shown in Fig. 15, that a living tree may be used as a means for collecting high-frequency energy from the ether. A spike may be driven in the tree near the top and connected through the

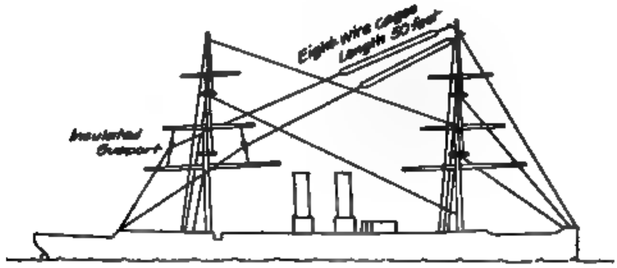



Fig 16.

detector, M, to the earth, the usual local circuit with battery, B, and telephone, T, being provided. This arrangement, the author understands, works quite satisfactorily, especially for emergency work, and a tree may be used as a part of a transmitting apparatus.

Fig. 17.

In Fig. 16 is shown the aërial conductor arrangement of the United States ship "Topeka"; some of the wire cages, previously referred to, are insulated at the mast head and at other places, with leads to the operating room near the stern of the vessel. At the extreme top between the cages there is a small spark gap, which during the trans-

mission of messages equalizes the potential on the two cages and their connecting wires.

Fig. 17 is a diagrammatic view of the circuit connections of a complete wireless telegraph receiving and transmitting outfit as installed on United States ship "Maryland." The direct current motor is driven off of the ship's circuit, an automatic starting box being provided. The motor drives an alternating-current generator at suitable speed to get the desired primary frequency. The energy from the alternator is used in the primary of the step-up transformer, the secondary supplying a closed oscillation circuit, inductance, spark gap, and condenser. The antenna has an anchor spark gap at the bottom so that the two halves of the antenna may operate in common in transmitting and independently in receiving. These matters of ship and other installations have now reached an engineering stage and the different control parts, instruments, etc., are mounted on a switchboard.

Fig. 17A shows this same system as installed in the operating room of the United States ship "Maryland." On the table in the corner are recognized the Leyden jars forming the oscillation circuit condenser. On top of it is the helix forming the inductance of the oscillation circuit. With its axis horizontal and at the top of the room is shown the antenna helix for effectively lengthening the antenna. On the small box on the table is shown the primary cell detector with switching apparatus, and upon the table is also seen the head telephone for the operator, comprising a watch-case receiver for each ear, the two receivers being connected by a band for holding them upon the operator's head.

The antenna helix near the top of the operating room is like the one in Fig. 17. It is a coil of bare wire upon a suitable frame, and the same frame carries on one side a hot wire ammeter which measures the amount of current flowing up the antenna. It may seem strange that an open-ended wire, like an antenna, can receive a current; but such is the case, and by a hot wire ammeter the amount is indicated. · The ammeter is used not merely to satisfy curiosity as to the amount of energy going up the antenna, but is a means for knowing when the inductance in the aërial path and the inductance in the condenser circuit are properly correlated for maximum effect. When these inductances are properly correlated a maximum of energy will flow up the antenna.

With the rapid advance of this art, and with its reaching an en-

tially continuous or sustained is shown in Fig. 19. A generator supplies current through a non-inductive resistance and choke coils to the terminals of an arc which may be placed in an atmosphere of hydrogen. In shunt to the arc is a circuit including a condenser, a telephone microphone, and inductance, the latter being variable and serving as a primary of an oscillation transformer whose secondary is connected between the aërial conductor and earth. The capacity and inductance of the circuit including the arc and microphone is made such that high-frequency oscillations result in the condenser circuit. These oscillations seem not to die out or dampen at all; one oscillation succeeds the other with substantially uniform amplitude, so that there is radiated from the aërial conductor into space a continuous stream of waves, not broken up into groups, as in the case of Fig. 4, for telegraphy. By talking to the microphone, the amplitude of the radiated waves may be varied, perhaps somewhat in frequency, but principally in amplitude. At the receiver these oscillations become high-frequency alternating currents of minute power in the aërial conductor and pass down to a detector of the self-restoring type. The detector, as the Pupin, Vreeland, or Fessenden detectors, or silicon detector, or any other suitable self-restoring detector, causes the response in the detector to vary in accordance with the rising and falling in the quantity of the received energy, with the result that the current through the telephone varies in like manner and, consequently, reproduces speech.

But even though the oscillations produced by the transmitting apparatus are not strictly continuous or sustained, nevertheless they die out at a rate which is extremely small compared with the rate illustrated in Fig. 2. It may be that such a transmitter delivers overlapping trains of very slightly damped oscillations. In any event, such a transmitter and receiver suffices for wireless telephony.

Or the transmitter may be such that the sparks occur extremely rapidly; indeed, at a frequency above the limit of audition in the receiving telephone at the distant station. Indeed, a spark gap at a frequency of from five to ten thousand will probably in most cases suffice. Then the amplitude of the radiated energy may be controlled by a microphone, and at the receiving station the operation above described takes place, with the reproduction of speech. Because the energy is transmitted in wave trains which succeed each other at a rate above audition, the detector at the receiving station responding at such high rate, there is no noise produced in the tele-

armatures is varied, and, therefore, the dielectric between the armatures is varied, with a resultant variation of the capacity of the condenser, 30, in accordance with speech. This then varies the natural period of the circuit of the main condenser, 24, in accordance with speech, so that the radiated energy, while remaining substantially constant in amplitude, varies in frequency in accordance with the human voice. At the receiving station the self-restoring wave detector, such as the Pupin or silicon detectors, may be connected in any suitable way, such as in shunt to an inductance, and such that it shall be responsive to frequency changes and thus cause in the telephone the reproduction of speech.

In Fig. 22 the same frequency variation is shown in a transmitter involving an arc producing sustained oscillations instead of separated

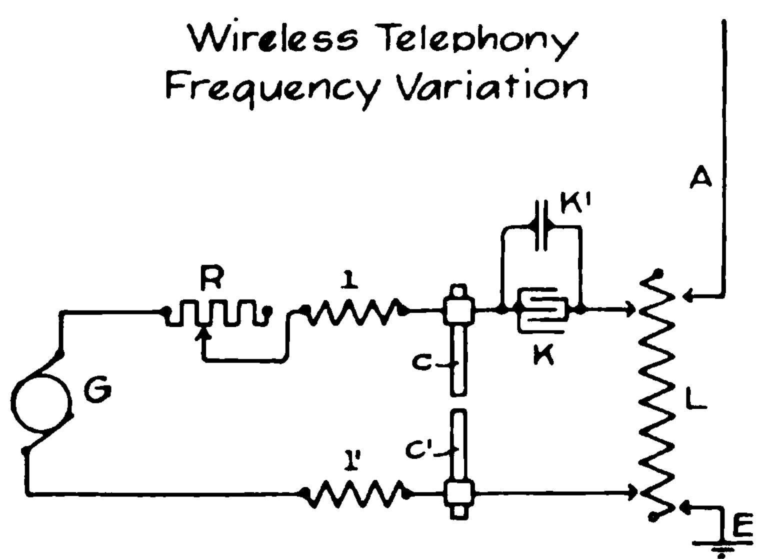



FIG. 22.

wave groups, as in the preceding figure. Here again speech uttered against the condenser, K, will vary the frequency of the transmitted energy by and in accordance with speech.

From Europe come reports that wireless telephony has been successful over distances of from 100 to 250 miles; and in this country, the author believes, several have been able to communicate over 100 miles. The arc system is generally used for such purpose, but there are inherent disadvantages in the arc system in getting sufficient energy into space. The arc system is quite suitable where relatively small amounts of energy are transmitted.

And from the fact that an ordinary microphone can safely handle only relatively small currents, the improvements are in the direction of controlling greater and greater amounts of radiated energy by the voice.

tric waves are much more easily transmitted at night than in daytime; that is, with a transmitter of a given power, messages can be received from that transmitter at greater distance at night than by day. It is attempted to explain this phenomenon from the fact that when the sun is shining the air between transmitting and receiving stations is affected by the ultra-violet light, which tends to make the air slightly conducting and thus absorb some of the transmitted energy. Of course, at night the ultra-violet light is substantially absent, and the air is supposed to be less conductive, with resultant better transmission.

I would say that the 1 per cent. variation in frequency was the limit on contracts by the Navy Department in tuning in wireless telegraph work. In wireless telephony by frequency variation it would be better to have the range wider.

Interference in such a case is within the bounds of possibility. If a telegraph transmitter is sending with a frequency which comes within the range of frequency variation in the telephone system, the telegraph signals may be superimposed upon the telephonic message.

Mr. Hering.—Has anything been accomplished in the direction of concentrating these waves so as to confine them to one general direction? I believe such attempts were made early in the history of wireless telegraphy, but I understand they never came to anything.

It has been claimed that the Atlantic cables would tend to lead the wave trains across the Atlantic in a general direction of east and west. A wave tends to follow the direction of a metallic conductor. Has such an effect been noticed in the transmission across the Atlantic?

Mr. Ehret.—I think your conclusion in general is correct. It has been attempted to concentrate the energy in its transmission to a given direction. From the base of the sending antenna a conductor has been extended out toward the receiving station in an attempt to confine the radiations within a certain plane. I believe that a measurable concentration within an angle of about thirty degrees has been attained, but so far as I know it is far from practical.

The case assumed by you in connection with cables is extremely improbable, because the cables lie at such considerable distances from the transmitting aërial conductors. I doubt whether the Atlantic cables assist in any way in the transmission of electric waves in the direction in which the cables extend.

Mr. Snook.—Directly bearing on this point, I am quite sure it is the experience of operators that they have not noticed any difference whatever in the character or the quality of the "ground" that they have obtained, when a submarine cable is near or far removed from the base of the aërial wire. Whenever they are able to obtain a good ground, the conductivity of the salt water is entirely sufficient to override the slight additional conductivity which would be given by the presence of the submarine cable.

Another point I failed to mention when reading Mr. Isbell's letter is in connection with the relative sensitiveness of this zinc oxide detector as compared with the sensibility of other detectors which are popular. Mr. Isbell says that when receiving messages coming from the western American coast he is able to receive messages clearly with the zinc oxide detector, but is unable to receive any signal whatever with the electrolytic receiver, which, at the time the zinc oxide detector appeared, was perhaps the most sensitive that had been discovered. He is able to make the coast hear him quite as clearly as points on his own side of the water.

this box the cable or wires were laid from a reel driven alongside the trench. The box was then filled with hot pitch, the cover nailed on, and the trench filled. No mention is made of manholes, but from the description given it is probable there were none, the various lengths of cable being spliced directly together in the wooden box.

In Philadelphia the earliest type of conduit used was the so-called "pump log" or creosoted wood duct, of 2½-inch bore. It was laid about the year 1886 on Market Street between the Delaware and the Schuylkill Rivers, and during the next few years on the north and south streets from South to Vine.

Following the use of this style of conduit, cement-lined pipe was laid quite extensively for several years, and was at first thought to be a great improvement over creosoted wood, and to be practically indestructible. Cement-lined duct consists of a thin wrought-iron shell, lined with Rosendale cement, and comes in 8-foot lengths with a 3-inch bore. It is provided with cast-iron ball-and-socket joints at the ends, to insure proper alignment and provide flexibility in making turns, and is laid with a concrete envelope in much the same manner as terra-cotta pipe. The troubles experienced with this conduit were many. The cement lining was found to drop off and obstruct the bore of the pipe, and the rough, gritty surface of the cement made it difficult to pull in cable. For these and other reasons its use was abandoned about the year 1896 in favor of the terra-cotta pipe, both single and multiple duct, so extensively employed at the present time.

The manufacture of terra-cotta duct may be said to date from about the year 1890, when several companies in the middle west started making it, notably in Ohio, where there are large deposits of the particular kind of clay best suited to its manufacture. In this form of duct has been found a nearly perfect conduit, one which meets all the requirements of practice, can be laid readily, is reasonable in first cost, and is practically indestructible.

The earliest form of tile duct was the single section; later came a multiple duct with three, four, six, and more holes. Both styles are good, but the multiple is somewhat less expensive than the single duct, hence it is now quite generally used in preference to the other form. The single duct was given its first trial by the telephone company at Wilmington in the year 1897, and proved so satisfactory that it at once became standard. No radical changes have been made in the style of pipe, in the method of laying, or in the general

problematical, there seems good reason to believe that when properly treated and laid it will last an ordinary lifetime. Practical evidence of its durability has recently been furnished by the conduit removed from Market Street during the construction of the subway. After fifteen years of service the pipe was found to be in practically as good condition as when first laid, and is now being used again for new work.

*Grading Trench.*—The bottom of the trench is graded so as to have a gradual slope from an intermediate point toward either manhole, which is termed "crowning," or an uninterrupted grade from one manhole to the other, with a fall of not less than 4 inches per hundred feet and preferably as great as 5 or 6 inches.

Grades are obtained by means of stakes driven in the trench at

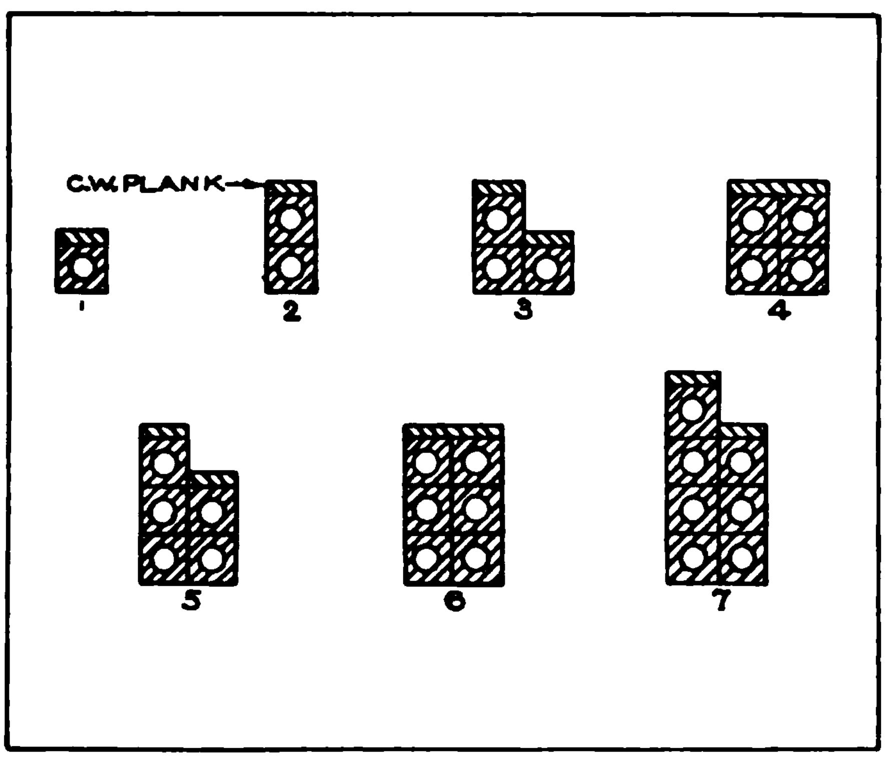



FIG. 1.—Standard cross-sections of creosoted wood duct.

intervals of 5 feet, three "tee" sticks being employed to set the stakes to the proper grade. The method of using the tees is to set one at either end of the trench and sight in the third at the various points between. Surveying instruments, such as level or transit, are rarely required in determining grades, though their use is sometimes indicated.

*Method of Laying.*—Standard cross-sections are shown in Fig. 1. The ducts are laid so as to break joints, both horizontally and vertically, and thus give strength to the structure. In joining the ducts the tenons and mortises are driven completely home, to form a tight joint. Except where laid on private property, a top protection of creosoted plank is used, 1½ inches thick and as wide as the duct

and the oval-shaped, depending upon the nature of the conduit, whether main or lateral, the number of ducts, etc.

*Rectangular Type.*—Fig. 14 shows a typical brick manhole in Philadelphia, where the size allowed by the city authorities is, as a rule, not greater than 4 feet wide by 4 feet 6 inches long. Walls are usually 9 inches thick, built of hard-burned brick of good quality. The "head-room" under the roof averages 4 feet 6 inches to 5 feet.

A brick floor, with sand joint, is used in the majority of manholes, to permit of free drainage through the floor into the soil. A concrete base is employed only in special cases, where the soil is wet or un-

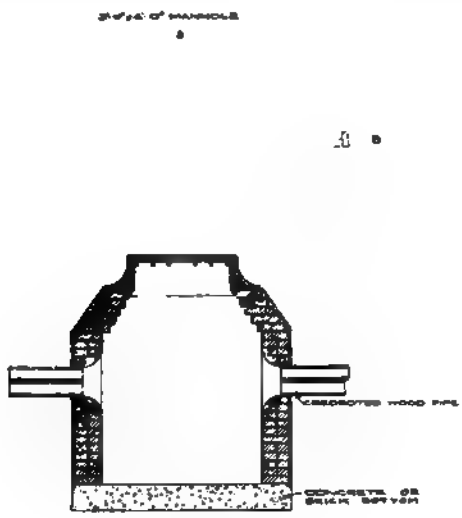


FIG. 14.—Typical Philadelphia manhole, size 3 feet by 4 feet.

stable. It is made 6 inches thick, and is covered with a 1-inch floor of Portland cement mortar.

Fig. 15 shows the special 2-foot 6-inch by 3-foot 6-inch brick manhole used at the end of lateral runs, and also over main runs where one or two ducts are cut, to provide for distribution purposes. It is 3 feet in depth and is provided with a rectangular manhole casting, in order to obtain the maximum working room when the cover is removed.

*Oval Type.*—In the oval type of manhole, used for heavy main runs outside of Philadelphia, greater length is obtained than is permissible

The rectangular casting is employed on distribution manholes (2 feet 6 inches by 3 feet 6 inches) and others which require a large top opening. The cover is 2 feet wide by 3 feet long, and the complete weight of frame and cover about 700 lbs. The objection frequently raised against a rectangular casting, that, if care is not used, the cover is liable to fall into the manhole and damage the cables, is not a serious one. In practice but little, if any, trouble is experienced from this cause.

### Obstructions in Trench.

Service pipes running across the trench are among the most frequent obstacles met with in laying conduit, and should be avoided, if possible, by running underneath them. With heavy runs, however, it is often necessary to divide the structure so as to pass above and below the obstacle. In this event the pipe should be surrounded with sand or earth, and further protected on either side by wooden blocking placed so as to prevent the conduit from resting directly on the pipe.

When sewer manholes are encountered, the difficulty can usually be overcome by running the conduit through one wall of the manhole. In extreme cases, however, where the manhole lies directly in the line of the conduit, it must be completely torn out and rebuilt to one side so as to permit the structure to pass. Inlet necks running from catch basins to sewers are easily taken care of by relaying with special bends.

### Special Construction.

*Bridge Crossings.*—For bridge work it was formerly considered necessary to employ wrought-iron pipe, but with the introduction of multiple duct there has come a radical change in methods of construction, resulting in a considerable saving in first cost, as well as a marked reduction in maintenance expense, which is one of the most important items to be considered in this class of construction.

The crossing of eighteen ducts on the Frankford Creek bridge (Kensington Avenue) furnishes a typical illustration of the newer methods. The bridge is of the plate girder type, with practically no space between the girders and the paving blocks. Consequently the only practicable method of crossing is by suspending the conduit from the under side of the girders. Seventeen U-shaped hangers are used, of 2-inch by ¾-inch wrought-iron, spaced on 11-foot centers,

siderably larger; as, for example, the office manhole opposite 406 Market Street, which is 7 feet 11 inches wide by 22 feet long, by 19 feet 6 inches deep (Fig. 18).

The work required about two years to complete and was accomplished with practically no interruption to telephone service.

## DISCUSSION.

Carl Hering.—How much protection, if any, do these conduits afford against electrolysis of the cable sheaths by stray currents?

Mr. England.—I might say that the terra-cotta and bituminized fibre ducts are of comparatively high insulation resistance as compared with the creosoted wood ducts. In actual practice, however, it has been found impracticable to depend upon the insulating property of the ducts to furnish protection against electrolysis, because the conduit cannot always be kept free from water or dampness. Even if the ducts could be made electrolysis-proof between manholes, there would still remain the difficulty of insulating the cables at the manholes. As a matter of fact, the danger from electrolysis is avoided by the use of a copper return bonded to the cable sheath at the manholes. In all cases where iron pipe, used as conduit, crosses bridges care is taken to insulate the pipe from the ironwork of the bridge so as to prevent the pipe and cables from picking up an excessive amount of current on the bridge.

W. C. L. Eglin.—It seems that the principal question raised is one of joints. There is a system of conduits that Mr. England has not touched upon, and that is the continuous concrete duct, which, I believe, was used in New York city some time ago. The principal feature of this duct was the use of paper envelopes of special oiled paper as a mold, the envelopes being inflated by means of an air-compressor. The paper envelopes were made in continuous sections and were laid between manholes in a conduit having a number of ducts. The paper envelopes were spaced by means of wooden racks. After the ducts were laid out for a section between manholes, all of the envelopes were inflated by means of an air-compressor and concrete was poured around them. As the envelope was flexible, it could be laid in any shape that the cable required, and could make small curves or bends around obstructions. It was claimed that the paper lining was an advantage in that it added to the water-tight feature of the conduit and made a smooth runway for the cable. It was also claimed that this type of conduit could be installed for less cost than either vitrified clay or iron pipe.

In regard to the water-tight feature: I agree with the opinion of others that it is impracticable to get a conduit that is perfectly water-tight and that arrangements should always be made for draining the ducts into the manholes.

Mr. England.—In regard to the continuous concrete duct mentioned by Mr. Eglin, I have had no experience whatever with this form of construction, although I have read descriptions of it. So far as I am able to judge, the method would be a wholly impracticable one to use, and it is doubtful if it would show a saving in cost. Whatever saving there might be in material, would probably be more than offset by the cost of inflating the tubes used for the interior forms. While the method might be considered interesting from an experimental stand-

of the perforated metal and cement joint, for the thin metal soon rusts out and the cement drops off. Even the concrete joint which I have described is not entirely free from this defect, although it is much more so than any of the other forms. The duct is scored near the end by small grooves running around the pipe, and this scoring insures adhesion between the concrete and the pipe.

SOLOMON SWAAB.—In conjunction with the Subway we laid upwards of 250 miles of terra-cotta ducts on Market Street, and it often struck me that a butt joint in terra-cotta telephone duct was not the best sort of a joint, and I think a bell and spigot joint could be devised which would answer the purpose. I understand that what telephone engineers principally require is to keep out the earth and the cement used in laying the ducts, and in this I am sure that they are not always successful. I have seen some obstructions removed from terra-cotta ducts; for instance, in a Bell conduit which was illustrated by Mr. England as located at Third and Market Streets. When it came to pulling in the cables, it was discovered that one of the ducts was obstructed, and one of Mr. England's assistants had us open the street and break into the duct, and we discovered that ice had formed in one of them. The water had undoubtedly gotten through the joints and frozen there. It seems to me that as they do not require an absolutely tight joint, some kind of a slip joint might be devised that would do away with the muslin or metal joint material.

MR. ENGLAND.—As to the duct with bell and spigot joint, mentioned by Mr. Swaab, there is a single-duct terra-cotta pipe made with such a joint, but no multiple duct, so far as I know. It would be exceedingly difficult to manufacture the multiple duct with the bell and spigot joint. So far as the single duct is concerned, the butt joint is considered superior, in practice, to the other form of joint.

JAMES HEYWOOD.—In power cable work one of the most important features is to prevent bending at a sharp angle by the splicer. The objection raised by the city authorities to large manholes is chiefly on account of the width, which interferes with parallel structures. A manhole 3 feet 6 inches wide and 9 feet long works very well on account of its extremely narrow construction. It absolutely prevents that sharp kinking of cables which is so dangerous to power cables.

I was much interested in Mr. England's paper, and particularly in the fact that he still continues to use wooden ducts. We have had wood ducts in service since 1893, and some of those taken out recently were pretty well rotted out. Another disadvantage of the wood duct for power cables is its tendency to take fire in case of a burn-out. Last week there was a burn-out in one of the up-town districts and the ducts were all destroyed, cutting off all power from the entire Kensington district. The fire also retards the progress of the work of repairing the cables. The ducts have to be torn up and taken apart and the fire extinguished before anything else can be done.

Cement-lined ducts were touched upon. We have had a large number of these in service, but found one of the objections is the cast-iron collar which is used on the end of the duct to provide a bell and spigot joint. This collar projects through the cement and comes in contact with the lead sheath of the cable. In cases of burn-out where large quantities of current are carried off to return cables and other ground construction, we find that a patch is burned out on the lead at each of

these collars. That, of course, applies to grounded railway circuits more than to metallic power circuits.

In connection with fibre ducts, the trouble from melting or sagging in the sun has been experienced by others, but I believe there are fibre ducts made now which do not do this. In fact, we have some of them in service. One of the chief advantages of the fibre duct is the possibility of aligning it nicely. Some of the bends shown by Mr. England would not be practicable for heavy power cables on account of the cable's extreme stiffness, and for this class of work the alignment feature is perhaps a little more essential than when the ducts are intended for telephone cables. The fibre duct presents a smooth surface on the inside and cables are readily drawn through it.

In connection with the matter of joints, it has been our practice to use, wherever possible, a quick-setting cement on the joints. We have had some experience with Portland cement, and find that it gets through the joints and forms little mounds or spikes inside which are hard to remove.

The multiple duct has advantages in its cheapness, but for our work has some disadvantages. The walls are thin, and consequently the cables are close together where they go into the manhole. Cables usually burn out at a bend, and the most severe bend is usually at the mouth of the duct, where the adjacent cable is likely to be damaged. With a thicker wall the liability to burn an adjacent cable is not so great, and the single terra-cotta duct has that advantage. It is also better in the case of excavations under the conduit, as the concrete envelope forms a very substantial beam which will support the conduit without shoring across a ditch 6, 8 or even 10 feet wide.

As to whether a duct should be made square or round, I understand that some of the service companies favor the square duct on account of the corners being able to receive small particles of dirt or stone when a cable is drawn in, without interfering with the cable. On the other hand, the round duct can be readily cleaned by plungers and other cutting tools, whereas the square duct has not that advantage.

PAPER NO. 1081.

# THE ORGANIZATION OF THE BUREAU OF SURVEYS.

E. J. DAUNER.
(Junior Member.)

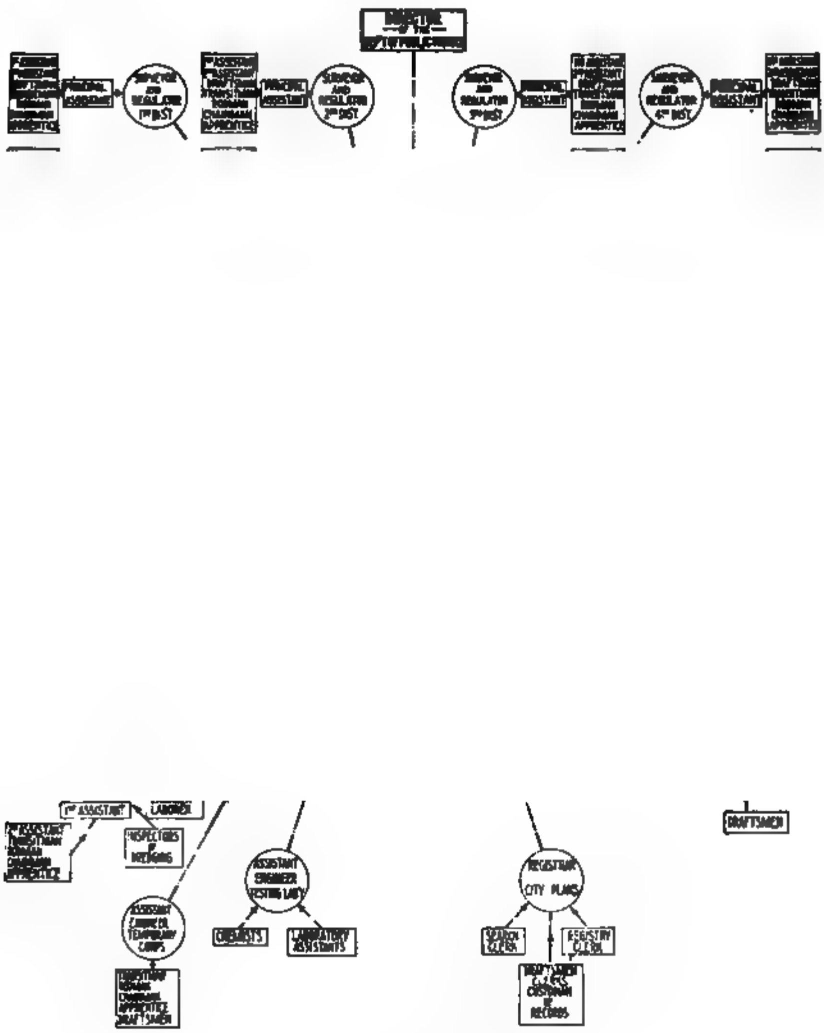
*Read before Junior Section, January* 11, 1909.

THE organization of the Bureau of Surveys dates from the second day of February, 1854; under what is known as the "Act of Consolidation," by which the various districts of Philadelphia were brought under the legislative control of the mayor and Councils, the city limits being extended to the county limits. The city was divided into twelve survey districts, one surveyor being elected to each district by Councils. Councils also elected a "chief engineer and surveyor," who, with the twelve surveyors, was to constitute a "Board of Surveyors."

The Chief Engineer, with the advice and consent of Councils, was to appoint the following officers: a recording clerk, who acted as secretary of the board and kept the minutes, and assisted generally in the office; a draughtsman; and a rodman, who acted as messenger.

All plans, records, etc., made by the district surveyors were to be the property of the city and to be turned over to their successors when their terms of office expired. The District Surveyors, in addition to their salaries, were allowed to make charges for work done for corporations or persons, according to a fixed scale uniform throughout the city.

On March 27, 1855, Councils in joint session elected Strickland Kneass to the office of Chief Engineer and Surveyor, together with twelve district "Surveyors and Regulators." These gentlemen met once and organized by electing Mr. Kneass president of the board. They performed no other duty, as they were superseded by a supplement to the Act of Consolidation dated April 21, 1855, directing that the members of the Board of Surveyors be elected by the votes of the twelve districts into which the city was divided; one to be elected in each, to serve for five years, "who shall have had five years' experience and skill in his profession." The supplement also directed




DEPARTMENT OF PUBLIC WORKS
BUREAU OF SURVEYS
ORGANIZATION
1907

plans of branch sewers in the districts, from standard specifications prepared by the Sewers Plans division, the final approval resting with the Board of Surveyors.

The construction of sewers, after the contract has been awarded, falls under the Sewer Construction division, an inspector from this being assigned to each sewer. In some cases where localities are not too widely separated an inspector will have charge of two or more sewers. His duties consist in seeing that the specifications and plans are followed by the contractor; in a diary he keeps a record of work done each day, amount of ground broken, trench opened to full depth, masonry constructed, number of slants and laterals built, amount of trench refilled, etc.

On completion of the sewer this book is turned over to the district surveyor for comparison and his signature. The sewer is then measured by the district surveyor and a plan prepared showing the requisite details, and bills are made out to the property owners along the street in which the sewer has been built. The plan and bills are signed by the district surveyor certifying to their correctness, and, with other papers, returned to the bureau. The bills are turned over to the contractor for collection, the city paying the difference between the total amount of the bills and the contract price. In the case of a private sewer, the entire cost is paid by the builder of the sewer, with a fee to the city for supervision of the construction and the district surveyor's charges.

Plans and bills for water pipe laid by the Bureau of Water are also prepared by the district surveyor.

Field work, estimates, and plans for grading and paving are prepared, and after contracts have been let the work is staked out, inspected, and when satisfactory certificates of completion given; in the case of paving, the property owner being charged his frontage and the city paying for the intersections of streets, frontage of non-assessable property, and public alleys.

The field work, calculations, and draughting for the preparation and revision of city plans are performed by the districts; the final approval and confirmation being given by the Board of Surveyors.

Jury plans showing properties affected and to what extent, in the opening of streets, in the revision of lines and grades, or the construction of a sewer, are prepared for the law department in the adjustment of damages.

copy of one prepared for the year [illegible] of the diversity and for 1906. It shows concisely and [illegible] employee and engineer to his im[illegible] [illegible] a voucher is issued the Director of the Departme[illegible] [illegible] charge therefor. This divisions in detail, the duties of [illegible] of Taxes at the City Hall, *The Board of Surveyors* is co[illegible] [illegible] receipted, it must be returned of the fourteen districts into [illegible] issued before the work is been mentioned; the Act of Twenty-fourth Ward, made [illegible] any of the city departments. The fourteenth district w[illegible] [illegible] into the city treasury in 1901, dividing the tenth [illegible]

The board sits regula[illegible] [illegible] approved February 2, month. Special meet[illegible] [illegible] October 16, 1905, Councils proposed changes in [illegible] grades of such streets as would Road day meetings [illegible] grade crossings of the Philadelphia meetings when ne[illegible] [illegible] Street to Butler Street, the work proposed changes i[illegible] [illegible] Railroad under the supervision of or against the sa[illegible] [illegible] to pay a stated sum to the rail- of the Board of S[illegible] [illegible] work. city plan or cha[illegible]

[illegible] ordinance approved October 13, 1906,

The Board [illegible] with the Philadelphia and Reading new tracks [illegible] to relocate, change, and elevate certain passenger r[illegible] Philadelphia, Germantown and Norris- structing [illegible] Street and Wayne Junction, and of the city plan, [illegible] Somerset Street and Richmond Street, for revisi[illegible] [illegible] might be abolished along these lines, the the boa[illegible] [illegible] the cost.

appro[illegible] [illegible] the work, consisting of the preparation of beds [illegible] for the construction and reconstruction of righ[illegible] [illegible] together with the examination of plans and

I[illegible] [illegible] by the railroad, and inspection of the work, dis[illegible] [illegible] of the grade crossings division. co[illegible] [illegible] Reading Railroad has since decided to make d[illegible] [illegible] a four-track road throughout. As the con- [illegible] called for the elevation of the present road, a [illegible] two-track only, a nice problem of adjustment [illegible] crossings division in the decision of just what [illegible] total cost the city pays half.

[illegible] *Division.*—Since the creation of the De- [illegible] Wharves, Docks and Ferries the work of this division

has been somewhat curtailed. Previous to the creation of this department the entire river and harbor improvement, as far as it concerned city expenditure, together with the maintenance, were under the jurisdiction of the rivers and harbor division. It is a hard matter just at present to tell where the jurisdiction of the one ends and the other begins. The matter of dredging, for example, there being no money available at present for this purpose, has been left in abeyance for future decision.

*Sewer Plans Division; Sewer Construction Division.*—These two divisions naturally fall together under the subject of sewers. As stated under the heading of the "Board of Surveyors," these divisions have entire supervision of the laying out, planning, and construction of the sewer system, or rather systems, of Philadelphia.

In designing the sewers, use is made of data collected by the district surveyors, and daily records of stream gages and pluviometers located in different parts of the city. Sewers are designed to carry a run-off due to a maximum intensity of three inches of rainfall per hour. This has been found to be ample; as, though in some few extreme cases the rainfall has exceeded this, once or twice an intensity in excess of five inches, the duration has been short—a few minutes—and confined to a small area, so that the sewers were able to take care of the extra amount of water.

In connection with this work a long series of observations to establish the relations between precipitation and run-off have been carried on; and from these an attempt has been made to give values to coefficients that affect run-off which would be of general application, at least in this city. While the practical results have been satisfactory, a sufficient number of observations have not yet been made to warrant the final adoption of a formula.

In the early days of sewer construction it was deemed sufficient to construct a culvert over a stream or to inclose it in a conduit. As the city spread these conduits were extended until they terminated at the banks of bordering rivers. The effect of this was to render streams unsanitary short distances away from built-up sections. In order to preserve the purity of streams, or to restore them to a state of purity, especially where they were depended upon to furnish water for potable use, the method of using intercepting sewers was later adopted, known as the "intercepting system," in distinction from the water carriage or combined system.

This system, first applied to the Schuylkill River to conserve the

The importance of this division in the prevention of useless breakages of paving and openings in the street can be readily appreciated.

*The Supervisors of Intercepting Sewers,* as their titles imply, have charge of the intercepting sewers. They inspect all connections made and keep an eye on the maintenance of the sewers.

*The Temporary Corps.*—This is a misnomer, as the temporary corps has been in existence for about twenty years. It is in reality a sort of utility corps, the men being used wherever needed in the different divisions.

*The Testing Laboratory* is little known except to those who have come into intimate contact with it in the course of business. Its work is constantly becoming more valuable, owing to the increasing amount and variety of materials used in modern construction, and the greater appreciation being given to the knowledge and importance of testing them.

In the basement of the City Hall is installed a complete cement and concrete testing laboratory. In operation here is one of the largest hydraulic compression machines in the world; its capacity is one million pounds. The concrete cubes tested are generally made on the site of the work from materials in the mixing box, so that the results of the tests not only indicate the general strength of concrete, but also give a value for the concrete in each particular structure. As, for example, in the construction of the Walnut Lane Bridge, when test cubes were made a record was kept as to what particular part of the structure the batch of concrete from which the specimen was taken went into.

In connection with this work is a freezing plant, and a furnace capable of developing a temperature of 3200° F.

The chemical laboratory is located on one of the upper floors of the City Hall.

A list of the tests made during the year 1907 will serve to show the scope and character of the work done in this department: Portland cement, natural cement, concrete, concrete materials, sand, stone, and slag, concrete building blocks, natural stone, artificial stone, paving brick, steel for concrete, boiler steel, theater curtain asbestos, tile, lubricating oils, illuminating oils, paint oils, paints, asphalt, and coal. A total of 2419 tests, in all, were made.

In addition, investigations of a research character are continually being made, to further the knowledge of the different materials, and

bers furnishing an index. All departments of the city government have access to the records, and the public also, in some cases upon payment of a small fee.

At the close of 1907 there were over 990,000 descriptions on file, and by this time the number is probably over one million.

*The Bridge Division.*—Prior to 1887 bridges were built under the Bureau of Highways; subsequently the bridge division of the Bureau of Surveys designed and supervised the construction of all bridges built by the city. There is very little that can be said of the work of this division without going into tiresome detail. It will be sufficient to mention the concrete arch bridge over the Wissahickon Creek at Walnut Lane, the latest example of concrete bridge construction, containing the longest concrete span in the world.

*The Pumping Station* is one that is maintained in the low-lying ground in the southern section of the city to prevent the accumulation of water.

*The Chief and Recording Clerk* is sufficiently described by his title; he takes the minutes of the board meetings and performs with his subordinates the usual duties of a clerical force.

The above description of the organization of the Bureau of Surveys, although short and of necessity leaving out a great many details, will serve to give some idea of how the city of Philadelphia copes with the engineering problems that confront the executive department of a large city. The Bureau of Surveys is essentially a bureau of construction, as, in the main, after the completion of work, maintenance and repairs fall to some other bureau or department.

# GOVERNMENT INVESTIGATIONS AND TEST OF FUELS.

**ADDRESS BY HERBERT M. WILSON.**
(Of the Technologic Branch of the United States Geological Survey.)
(Visitor).

*Read December* 18, 1909.

THE technologic branch of the United States Geological Survey operates under three acts of Congress and follows three separate lines of investigation. One is the investigation and testing of the strength and durability of structural materials. (It is perhaps not generally understood, but these tests and investigations are by law strictly limited to materials belonging to the United States.) Another line of investigation covers the testing of coal and other fuels; and a third—the outgrowth of the numerous disasters and loss of life in mines—has to do with the investigation of mine accidents, to determine their causes and possible means of preventing them, and to secure greater safety in mining.

The fuel investigations arose from an appreciation of the fact that the fuel as used by the Government, and consequently by others, is not economically used, nor economically produced, and that there is considerable waste thereby. This has been accentuated in the last year or so from the investigations of the National Conservation Commission, which has thrown much light on the possible life of our fuel resources. The United States produced in 1908 over 415,000,000 tons of coal—a tonnage which exceeded considerably that of any other country in Europe, the next being Great Britain, with 292,000,000 tons of coal, with Germany a close third.

The production of coal exceeds very greatly that of the two precious metals, gold and silver; in fact, it is nearly double the combined production of all of the metals excepting iron. In 1880 the production of coal was only slightly in excess of that of gold and silver together, the latter production being nearly $71,000,000, that of coal $95,000,000; whereas in 1907 the production of coal was five times greater than that of the two precious metals. The increase in coal production in the United States, concerning which a great deal has been written in the papers since the report of the Conservation Commission, is, as you will observe, on a very rapidly increasing ratio. In

the period 1846 to 1855 only 8,000,000 tons of coal were produced in this country. The tonnage increased thence up to the period 1876 to 1885, when it was 84,000,000 tons. During the period 1896 to 1905 it increased to 283,000,000 tons, and in the last six years it increased to 436,000,000 tons.

Much that has been misleading has been written and said about the subject of the duration of the coal-supply. One theory is that the middle of the coming century will see the end of the coal-supply in the United States. Another is that it will last for about seven thousand years. Both guesses are about equally good, depending on the method of estimate. On the present increasing basis of production it would not take much over a century to utilize all the coal in sight in the United States. If, however, the annual production continue as now without increase, the coal-supply might last about seventy centuries. Many believe that the approaching scarcity and consequent increase in price of coal will teach us to use it more economically and to conserve the supply accordingly.

The "per capita" consumption of coal has been more than keeping pace with the increase in production. In other words, coal is being used in the industries at an increasing rate, which is represented by the use for 1880 of 1.4 tons per capita; 1892, 2.3 tons per capita; and 1907, 5.4 tons per capita per annum.

The Geological Survey is bending its energies toward finding out how the fuel-supply of the United States may be increased. This is being done by the geologic branch, mapping the coal deposits and furnishing samples on which the fuel division is making tests and analyses. This contemplates two lines of investigation:—one into the distribution of the coal in the country and sources of waste in mining and marketing it; the other having to do with the utilization of the coal, and the ways and means whereby the various coals may each be put to that use which will be most efficient, and thus conserve the supply.

The coal fields—to pass over them quickly—are well known to all of you. In this part of the country our tendency is to think of the eastern coal fields as the great source of supply of the country, yet on the map it is an insignificant area. The bituminous coal fields of the east, the bulk of which you think to be in Pennsylvania, are most extensive in West Virginia, Ohio, and Kentucky, thence to Tennessee and Alabama. There is a large coal field in Arkansas. In Texas, the Dakotas, and California there are large areas of lignite. In Oklahoma

of the coal which was being bought. Mine shafts, as I have said, tap more than one body of coal, and there may be a vast difference in the quality of the coal coming from those bodies through the same tipple. The modern method of purchasing coal, that which is being adopted by many large buyers, and which is now almost exclusively employed by the Government, is the B.T.U. basis, or the ash basis in the case of anthracite, and all of that is done under the supervision and inspection of the Geological Survey.

About 700 samples a month are received in the Washington laboratory, coming from the Government buildings under the direction of the Treasury Department, samples covering nearly the whole country, from Los Angeles, California, to Eastport, Maine, and about forty separate Government buildings in the city of Washington, from a number of arsenals, various navy yards, and other sources of Government purchases. There was much opposition to this method of purchasing coal at first, but there seems to be much less of late, and there seems to be a better understanding as to the obligations of sellers and buyers; and it would seem that when the matter can be better understood, and the question of sampling can be better adjusted, and the calibration of the calorimeters can reach a point where those of private chemists, to which the coal companies send their check samples, will be in accord with the standard calorimeters of the Government, there will be less cause for friction than now.

In the first years of fuel-testing the Government inspectors sampled about 300 different kinds of coal in carload lots. Steaming, gas-producer, briquetting, coking, washing, and other tests were made on each coal with a view of determining the most efficient use of each. As a result it has been found that a coal from one field which can be used most economically for one purpose, say for producing steam, may not be economical for house-heating boilers or for gas-production.

Taking from these tests a few typical ones showing the character of the coal, it was found that West Virginia coal produces the greatest number of heat units, which run close up to 14,500 B.T.U.'s per pound, as received. Pennsylvania No. 4, a particular type of Pennsylvania bituminous coal, is next best, running about 14,000 B.T.U.'s per pound. From this, coals run down in B.T.U.'s through the various States to North Dakota lignite, which is lowest in B.T.U.'s. A somewhat fixed relation will be observed between the heat units in the coal and the amount of fixed carbon, the West Virginia coal having the

of an agent of the dealer, samples the coal. A fairly good sized sample is taken,—probably sixty-five pounds in a ten-ton delivery,—a scoop-full at a time. That is taken to the laboratory and reduced in a crusher so as to get a fair can sample, and gradually worked down to a laboratory sample, which is then analyzed. Checked samples are kept in sealed cans in case of controversy, until final settlement is made.

Turning to another feature of the fuel work, that of the possibility of conserving the supply through a more efficient use of each kind of coal, it may be known that in many steam-boiler plants of the country, that of the latent efficiency in the coal, something less than 6 per cent. is turned into useful work, 94 per cent. being wasted. The best steaming practice is that of the Interborough Rapid Transit Company of New York, or the Commonwealth Edison Company of Chicago, by which as much as 10 per cent. of the latent efficiency of the coal has been converted into useful work. The waste has been very carefully analyzed and is distributed about as shown in the diagram:

| | Heat Units. |
|---|---|
| Put in the furnace, about | 13,500 |
| Lost in the ashes | 135 |
| " " boiler radiation | 675 |
| " " steam | 10,500 |
| " " pipe radiation | 210 |

A certain percentage is lost in delivery to the auxiliaries and in the exhaust; a large proportion goes up in the gases through the chimney—2970 B.T.U,; there are delivered to power 1273 B.T.U.; there are rejected to the condenser 103 B.T.U., until finally there are delivered to the belt only 1171 B.T.U.

Of the very large loss shown as going up the stack, there are visual evidences in the carbon of the pall of smoke hanging over our cities, and it is known that there are greater losses in the unconsumed gases. The engineers of the Survey, after an investigation of something like 280 of the best power plants of the country, and after making many tests of the Survey fuel plants, with practically every coal available in the United States, have found that nearly all can be burned in some form of apparatus without the production of smoke, and consequently without the loss of carbon in the smoke and in the gases, and with an increased efficiency and a reduction in amount of coal used.

tubular boiler in a hospital building or a large barracks. Here shipments of coal purchased by the Quartermaster's Department are received from all parts of the country, in amounts of 2000 pounds for each shipment, and tests are made of it in different types of boilers and with that type of firing which will produce the greatest efficiency from the cheapest coal available.

There are some interesting relations between the volatile matter in the coal and the efficiency of house-heating boilers, which are of particular concern to the people in the central part of the country where they have the volatile coals, such as those of Indiana, Illinois, and Iowa. For instance, the volatile matter in the combustible has ranged in a series of tests from 18 to 22, 34, 38, and 44 per cent., and as the volatile matter increases from 18 per cent. to 44 per cent., so does the efficiency decrease in percentage, owing to the fact that much of the volatile matter passes out of the stack unconsumed, the efficiency being 60 per cent. with a coal containing the least volatile matter, and diminishing to 47 per cent. for the coal having the greatest amount of volatile matter. The percentage of black smoke bears out the statement just made, to the effect that with the lowest volatile matter there is the lowest percentage of black smoke—18 per cent.; and with the highest, 44 per cent., there is over 33 per cent. of black smoke.

There is a similar relation between the percentage of $CO_2$ and the CO in the dry flue gases, showing that the uncombined gases are carried out with the smoke in the same proportion.

Realizing that there is a certain critical length of travel for the volatile gases driven off in heating coal, for each type of coal, at which the highest efficiency will be produced, the Survey has constructed what is called a "long combustion chamber"; namely, there has been built out from one of the 210 HP. boilers a furnace or combustion chamber of absurd length, 40 odd feet, so as to get the maximum length of travel for the flue gases and afford them an opportunity to mix with the air, and in this is being studied the behavior of these gases. There is a mechanical stoker and the combustion chamber is made semi-arched. It is well insulated, being lined with fire-brick, and then there is an air-space and an outer lining of common brick, and that feature has developed some important facts. At every five feet along the length of this chamber are peep-holes through which pyrometers may be inserted to take temperatures and for gas sampling. There are some similar holes

bituminous coals, lignite, and peat. In the Survey testing plant no difficulty whatever is experienced in operating gas-producers on long runs of a week on any fuel. Recently a test was run on Rhode Island coal, almost a graphite, from a field abandoned for years because it was considered of no value for steaming, yet it developed the full load of the engine on a four-day run, with practically no clinkering and very little ash. As for peat, a run on 40 tons of Michigan peat is now being made.

The depth of the coal-bed in the producer is 6 to 8 feet. The distillation zone has a temperature from 700° to 1300° F. The decomposition takes the form of breaking up $CO_2 + C$, resulting in 2CO and $H_2O + C$, resulting in $CO + H_2$ at a temperature of about 1900° F. The combustion zone lower down has temperatures about 2000° F. There are holes in the side of the producer, as in the long combustion chamber, for taking pyrometer measurements and gas samples from all portions of the fuel-bed, and by this means some interesting things have been discovered which will have an important development on the future design of producers. These results show the things that are detrimental to efficiency; dead spots and sluggish action in travel of the gases, and low temperatures along the edges. The chemists have found $CO_2$ being produced in the cooler portions where CO might be produced, and that the proper reactions are not carried on because the proper temperatures are not maintained throughout the producer. Through slight changes it is believed that ere long, with this knowledge, it will be possible to get much greater efficiency from the gas-producer than now.

A comparison of coal from different parts of the country when converted into energy through the steam-boiler is very interesting. The gas-producer, when operated in the very best way with Virginia coal, produced 3.3 times as much efficiency as a steam-boiler of the best type operated in the best way in testing practice. Likewise for certain Pennsylvania coal we get a ratio of 2.8 times the efficiency with the gas-producer as against the steam-boiler.

Using the best West Virginia coal under the steam-boiler, and the lowest grade of lignite in the gas-producer, the poorest grade of coal produced about the same efficiency, that is, the same number of electrical horse-power, in the producer gas plant as did the best steaming coal used under the boiler.

On the average, taking the poorer grades of commercial plants throughout the country, there are 95.2 per cent. losses in the steam

with a view of determining how they may be minimized, and incidentally to doing that, it has developed that the best way to find out the causes of mine disasters is to go into the mine right after the disaster has taken place, and study the same at first hand, while it is possible to get the temperatures as they are then; and before ventilation has been turned on, to get samples of the gases, and, in short, to study the conditions before operations have been resumed. It was found that this could be done only by the use of some artificial breathing apparatus, so that while the men went into the mines after disasters merely as students, and the state mine inspectors and mine-owners were waiting to get into the mines, or, that is, waiting for them to become safe for human life, there was forced upon the Survey engineers the need for their assistance in rescuing those who were caught below.

In regard to rescue work, the government engineer is frequently called upon for advice, which is given freely, but he has no authority to direct what shall be done.

In the beginning of the inquiry into mine accidents it was found that the death-rate in coal mines in the United States was on an increasing ratio. In 1895 there were about 2.7 persons killed per thousand employed in the mines, and the ratio has gradually increased to 1907, when it was about 3.3 persons killed per thousand. Great Britain, where years ago they undertook to investigate the disasters in mines and to develop methods of protecting the lives of miners, from 1860 to 1895 had less than half the number killed in the United States. We are killing 3000 men a year and maiming or injuring a great many more. Great Britain now has her ratio down to a little above one per thousand. The Belgium mines are naturally the most dangerous to work in the world. Belgium has made the most progress in the reduction of mine accidents and remedial measures: In 1880 it had a ratio of 3.3 killed per thousand, and now it has something less than one per thousand killed.

Of the appropriation for mine accident investigations 90 per cent. is spent in Pittsburg in laboratory investigations, and the other 10 per cent. is spent in substations in different parts of the United States. From these stations men are available to go into the mines and study them and learn something about the methods of mining coal, so that reports and information may be disseminated which may be valuable as a guide to miners and mine-owners.

The principal piece of apparatus in Pittsburg is a miniature mine

gallery 100 feet long and about 6 feet in diameter, having openings along the side at about every 6 feet and pieces of plate glass through which the travel of the flame from an explosion can be watched. One end of the gallery opens into the air. The other end is fastened in concrete in which is embedded a cannon. In this cannon is placed a sample of the explosive found in a certain coal mine. This is fired and the effect noted in the gallery. As a result of these tests, certain facts have been developed and certain information gathered which is undoubtedly going to have an influence in reducing the loss of life in coal mines. All the explosives found in the mines have been tested by detonating them in the presence of known amounts of coal-dust, the amount fixed by calibration, practically a pound per foot, to simulate the way it may occur in the mines, and in the presence of mine gases consisting of known percentages of methane mixed with air by a fan. In the beginning it was found that so-called "safety" explosives would detonate the gas or dust and cause an explosion, and that certain other explosives would not. At first there were few explosives on the market which would not ignite an 8 per cent. mixture of mine gas in air and which would not cause an explosion of coal-dust. The manufacturers, as the result of the record of these tests, quickly produced the kind of explosive wanted, so that last May it was possible to issue an official list of "permissible" explosives, or of those considered safe for use in gaseous and dusty coal mines. The American tests are somewhat more severe than those of any other country, yet since May there have been developed so many more permissible explosives that there are now thirty-one that have been passed, and the manufacturers are making others just a little better, and applications are now in for testing up to forty-six.

The greatest mine disasters in this country have been produced by coal-dust explosions. When mine gas is ignited, the explosion is local in that part of the mine where the gas is exploded. An explosion of coal-dust is greater at the end of a thousand feet than at the beginning. Such is the kind of mine disaster that occurred at Monangah, West Virginia, a few years ago.

## DISCUSSION.

CARL P. BIRKINBINE.—How does Texas lignite compare with the lignite from North Dakota?

MR. WILSON.—I cannot say that there is sufficient difference to be worth mentioning. We found that with Texas lignite, and six carloads from California and some from North Dakota, we were able to briquette one about as success-

fully as the other. So far as gas-producing qualities are concerned, they are about equal. There are slight differences, not sufficiently pronounced for me to recall them.

J. C. Trautwine, Jr.—How do you account for the fact that the intensity of the explosion increases with the distance through which the explosion has to travel?

Mr. Wilson.—It is accounted for first because there is more dust blown into the air by each succeeding detonation, the action being that of a succession of explosions. At the point where the explosion begins only a small percentage of the dust is ignited, but this is rapidly added to and the volume is increased until all the dust, from one end of the chamber to the other, is within the detonating zone. Like cement manufacture, a great deal depends upon the fineness of the dust. The first explosion ignites the dust, and as it progresses it ignites the remaining dust, and so gathers force to the end of the mine gallery.

President Dallett.—Do you not think rather that the intensity of the explosion is due to the compression? If you take a mixture of coal-gas and air and explode it under atmospheric pressure, as the original explosion takes place the intensity of the explosion is much less than where you have a high compression to start with, and as the explosion travels on, you get a higher compression than at the point where the explosion takes place.

Mr. Wilson.—Undoubtedly so. The Survey is publishing a bulletin describing tests of the explosibility of coal-dust. It shows the tests made in the gallery to determine methods of moistening the dust, or mixing with shale-dust, or mixing it with calcium carbide to deaden its effect. We found you could wet it with almost 30 per cent. of water and it would yet explode under favorable conditions; even dampening it does not always make it a non-explosive. What is wanted is to maintain in the mine conditions similar to those present in the humid and warm days of summer. You may have noticed that the coal-dust explosions nearly all occur in the early winter. We rarely have them in summer. The mine is dried by ventilation in the winter, whereas in summer-time it is not so dry. How to drive air into the mine, commerically, so as to keep its temperature and humidity fairly uniform in the winter as in summer is the question. This is fully set forth in the bulletin referred to.

P. A. Maignen.—After one of these explosions is there any $CO_2$ present, or CO?

Mr. Wilson.—Methane is present in large quantities; frequently CO, but more $CO_2$.

Mr. Maignen.—Does it come from the explosion or from the mine gases?

Mr. Wilson.—It comes from the explosion of the mine gas or coal dust, the analyses of which have shown in some cases as low as 10 per cent. of O after some explosions and a pretty high percentage of $CO_2$.

Mr. Maignen.—If the $CO_2$ were present in some way or other, would that improve the case?

Mr. Wilson.—In most cases we have known there was not enough oxygen to sustain life and the amount of $CO_2$ present would doubtless produce death.

E. M. Nichols.—Is there any loss in value between briquetted coal, taking into consideration the cost of briquetting, and run of mine coal?

Mr. Wilson.—I do not believe we know enough about briquetting yet to

know in many cases whether it is commercially a paying proposition. Everything depends upon the price of coal at the mine and the success of the owners of the plant in keeping it in constant operation. At a plant like our testing station we have a let-up of a day or two while fixing up the machinery, and then have a good long run of six, eight, or ten hours' operation. We find that many of the cheaper grades of coal can be briquetted at a price which is profitable. If the mine is near a railroad, say in Missouri or Arkansas, and you get the coal at the mine at eighty cents or a dollar per ton, and the briquetting process costs $1.50 a ton, the whole costs $2.50 a ton, and will compete very favorably, at that point, with coal coming from Illinois that costs $3.50 per ton. That is the condition. If you can briquette it at such a price that it will produce a fuel which is worth $2.00 or $3.00 a ton, which will compete with a better grade of coal of higher price, it will be profitable.

Dr. H. M. Chance.—Is anthracite dust as liable to explosion as bituminous dust?

Mr. Wilson.—No. I was present on two occasions where anthracite dust was used, but no explosion was produced under conditions which would have ignited bituminous dust. Doubtless anthracite coal-dust will ignite under favorable conditions.

Dr. Chance.—Another phase of the matter has occurred to me, and that is the accuracy with which the B.T.U. determinations can be made. In looking up the records of some tests, I find that in the calorimetric tests the units were only taken to the third place; that is, 2.54. Sometimes I believe they read to thousandths, which would be one part in 10,000. How accurately, or how close, would you expect two determinations to check made by your own men, say each taking his own sample, and letting the determinations be made entirely separately—what would be the expected comparison of the B.T.U.'s?

Mr. Wilson.—I do not think you can rely upon any single calorimetric determination being within much under 50 B.T.U.'s. Taking as we do a number of determinations and averaging them, I think we can readily report them down to 10 B.T.U.'s. We do not think it is worth trying to get nearer than 50. As a rule, we have found the trouble is that commercial chemists use coal for calibrating their apparatus, and that is absolutely impossible as a calibrating material. We use sugar or some pure carbon substance like that.

Dr. Chance.—I imagine the calorimeter is more accurate than the sampling. Where duplicate samples are taken of the same shipment by different samplers, I would like to ask what variation is found in B.T.U. determinations.

Mr. Wilson.—You can get very wide differences in determinations in sampling. The only thing we found possible was to have an established method of sampling which is taught our inspectors, and we find we can get fairly uniform results from samples taken by two men trained in the same methods of sampling. When we sample the deliveries, there is a reasonable accord, although it will not stand comparison with sampling by others. The getting of samples is one of the questions now requiring the most careful inquiry and study.

Dr. Chance.—What I would like to know is how nearly the sampling of the same shipment made by two men trained by the department in the same methods of sampling would check.

Mr. Wilson.—With high-grade coal we will get very close accord, and with

poorer grades we have wide variations, because the slaty matter is distributed unevenly in the car and in the various sized lumps composing the carload. We often have some trouble with the laboratory samples. After we get the specimens parted down to 4-pound samples and then begin to grind it, even for laboratory samples we have some difficulty.

A. E. Lehman.—What is the method of sampling from large and small shipments, say with carload lots?

Mr. Wilson.—Our largest car sampling is for coal delivered to the Panama Canal. There are two ships a week going there. We tried sampling every tenth car, and then every fifth car. Our method is for a man to stand by with a scoop and accumulate a large sample of a ton or more, then spread it on a blanket and mix it up, quarter it, and then pass the quarter through a sampling machine, which is a bucket with a vertical compartment in it; and then it drops through another bucket which parts it again, and so on until we get it down to a laboratory sample.

S. E. Fairchild, Jr.—How about the lumps in the middle?

Mr. Wilson.—Well, that depends upon the sampler himself. As he uses his scoop he tries to get as much lump in one sample as in another. We have experimented until we have gotten down to a fairly uniform method of sampling. The big dealers have their own men on the wharf, and if they can trip our people up, they are going to do it, yet we have had no complaint, and I think we are working nearly uniformly in that direction. We have checked samples in the mines and in transit, getting a sample in the mine and getting another from the same car at the wharf, and in that way we get data on the loss or increase in moisture in transit, and the increase in ash, etc.

Dr. Chance.—The sampling and buying of coal along these lines is getting to be quite a fad. I think the reason things are working so smoothly between the contractors and the bidders is that the bidders understand the methods adopted by the government, and in that way things work out all right, but it does not follow that the results are truly representative. To do it right might cost $10 a ton, or ten times more than it is worth. On large contracts it might be true economy to adopt these methods and incur the labor and expense, but in the purchase of coal in small quantities I think it is absolutely impossible to carry out this plan without involving an expense many times the value of what would be gained. I would like to ask Mr. Wilson as to the personal equation between two different samplers as found by actual practice in sampling, say in sampling the same coal by the same method. I have had a number of cases of that kind myself and have never been able to get satisfactory results. The same men will get different results at different times even when using the same method of sampling.

Mr. Wilson.—I agree with what the speaker says, but I cannot answer him satisfactorily now. I will be glad, however, and will with a great deal of pleasure answer all communications in the greatest detail, if you will give me the details of some particular case.

I doubt if this method is profitable for small consignments. For the government, however, we find it profitable on some of the smallest deliveries, whereas it would not be profitable for small consumers; that is probably because we have inspectors who are available and have a laboratory, etc.

The navy yard at Washington agreed to have its buckwheat anthracite

purchased on the B.T.U. basis, and the samples were analyzed by us. After we first started in, the penalties were so heavy that the contractor was up in the air, as they say. We did the best we could for him and told him how his coal was running; he claimed that he was sending word back to his operator and that they could not do any better, and another contractor who was delivering 7500 tons was having the same trouble. The coal was running about 22 per cent. ash. Inside of a few weeks their coal was down to 16 per cent. ash, which they have been delivering steadily since. They found just where their coal was coming from and are now delivering it according to specifications.

# ABSTRACT OF MINUTES OF THE CLUB.

Business Meeting, November 6, 1909.—The meeting was called to order by the President at 8.40 p. m., with 179 members and visitors in attendance. The minutes of the Business Meeting of October 16th were approved as printed in abstract.

The President announced that at a meeting of the Board of Directors, on November 1st, the resignation of Mr. Philip L. Spalding as vice-president of the Club had been accepted, that Mr. Henry Hess had been elected vice-president to fill Mr. Spalding's unexpired term, and Mr. W. L. Plack elected member of the Board to fill the unexpired term of Mr. Hess.

Following a report of the tellers on the election of members, the President declared that Thomas Hugh Boorman was elected to Active Membership, and that Herbert McMillen Dibert, Harold Goodwin, Jr., Clarence Bayne Kelley, and James Clawson Roop were elected to Junior Membership.

The following report was then presented by the tellers on the ballot for the amendment to the By-Laws increasing the dues of Resident Active and Associate Members from $25.00 to $35.00 a year: For the amendment, 190; against the amendment, 79; necessary for approval, 179, the amendment thus being carried by 11 votes.

Mr. A. M. Herring, visitor, presented the paper of the evening, entitled "A Few of the Engineering Problems Involved in the Design of the Aeroplane." Following the paper, moving pictures were exhibited, illustrating the flights of various types of aeroplanes at Rheims.

Upon motion of Mr. Swaab, a vote of thanks was extended to Mr. Herring for his extremely interesting paper.

Upon motion, the meeting adjourned at 11 p. m.

Business Meeting, November 20, 1909.—The meeting was called to order by the President at 8.35 p. m., with 105 members and visitors in attendance. The minutes of the Business Meeting of November 6th were approved as printed in abstract.

The President announced the death of Mr. George T. Barnsley, President of the Engineers' Society of Western Pennsylvania and Active Member of this Club. Mr. Barnsley's death occurred on October 23, 1909.

The Committee on Nominations reported as follows:

*For President* (to serve one year)—Wm. Easby, Jr.
*For Vice-President* (to serve three years)—Charles Hewitt.
*For Secretary* (to serve one year)—W. Purves Taylor.
*For Treasurer* (to serve one year)—E. J. Kerrick.
*For Directors* (to serve three years)—David Halstead, J. A. Vogleson, Percy H. Wilson, F. K. Worley.

Mr. H. C. Berry, Active Member, presented the paper of the evening, entitled "The Rating of Pitot Tubes for Use in the Test of a Niagara Power Plant," which

was discussed by Messrs. Wm. Easby, Jr., W. M. White, John C. Trautwine, Jr., and others.

Upon motion, the meeting adjourned at 10.30 P. M.

BUSINESS MEETING, December 4, 1909.—The meeting was called to order by the President at 8.40 P. M., with 143 members and visitors in attendance. The minutes of the Business Meeting of November 20th were approved as printed in abstract.

Following a report of the tellers, the President declared that Horace G. H. Tarr was elected to Active Membership and James Morgan Harding to Junior Membership.

Dr. Henry Leffmann, Active Member, presented the paper of the evening, entitled "Diamond Mining," which was informally discussed by Messrs. John C. Trautwine, Jr., John C. Parker, S. M. Swaab, Wm. Easby, Jr., James Christie, Wm. C. Furber, H. C. Snook and Frank Burns.

Upon motion, the meeting adjourned at 10 P. M.

BUSINESS MEETING, December 18, 1909.—The meeting was called to order by the President at 8.35 P. M., with 121 members and visitors in attendance. The minutes of the Business Meeting of December 4th were approved as printed in abstract.

The President called to the attention of members that "Club Nights" would in the future be held on Thursdays, instead of Fridays.

Mr. Herbert M. Wilson, visitor, presented the paper of the evening, entitled "Government Investigations and Tests of Fuels." At the close of his paper Mr. Wilson also described the work of the government in connection with the prevention of mine disasters. Messrs. Carl P. Birkinbine, John C. Trautwine, Jr., P. A. Maignen, E. M. Nichols, H. M. Chance, A. E. Lehman, S. E. Fairchild, Jr., Francis Head and others took part in the discussion. Upon motion of Mr. Head, a vote of thanks was extended to Mr. Wilson.

The meeting adjourned at 11 P. M.

# ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS.

Regular Meeting, November 1, 1909.—Present: President Dallett, Vice-Presidents Devereux and Easby, Directors Clarke, Head, Quimby, Twining, Christie, Cochrane, Hess, Gwilliam, Hutchinson, Mebus, the Secretary, and the Treasurer.

Mr. Spalding's resignation as Vice-President of the Club was read and accepted, and Mr. Henry Hess was elected Vice-President to serve the remainder of Mr. Spalding's term, expiring February, 1912. Mr. W. L. Plack was then elected a member of the Board of Directors to fill the place of Mr. Hess, term expiring February, 1911.

The resignations of David Pepper, Jr., and E. J. Hasse were read and accepted, as of even date.

It was moved and carried that the House Committee be authorized to organize a movement toward the development of the social side of the Club, and that it be empowered to give entertainments, to appoint suitable committees, and otherwise act in this matter as seemed most expedient.

Upon motion, the meeting adjourned, to continue on Monday, November 8, 1909.

Adjourned Regular Meeting, November 8, 1909.—Present: President Dallett, Vice-Presidents Easby and Hess, Directors Twining, Cochrane, Gwilliam, Hutchinson, Mebus, the Secretary, and the Treasurer.

Letters from Mr. Henry Hess and Mr. W. L. Plack, formally accepting the offices of Vice-President and Director, were read.

The resignation of Mr. H. E. Hutchins was read and accepted, to date from December 30, 1909.

Following an informal discussion of Club affairs, it was moved that a committee of three be appointed to formulate and draft schemes for the improvement of the Club-house, and to present the same to the Board.

Regular Meeting, December 4, 1909.—Present: President Dallett, Vice-Presidents Devereux and Easby, Directors Clarke, Head, Quimby, Twining, Christie, Cochrane, Develin, Plack, Gwilliam, Hutchinson, Mebus, Wood, the Secretary, and the Treasurer.

The Treasurer submitted the monthly statement of the accountants, and reported that a loan of four thousand dollars for sixty days had been negotiated with the Colonial Trust Company.

Upon recommendation of the Committee on Membership, the following members were advanced in grade:

From Associate to Active: Houston Dunn.

From Junior to Active: Wayne B. Morrell, Edwin S. Young, Francis R. Berlin, H. R. Wilkinson, Edward M. Bassett, Frank H. Rogers, Edward E. Krauss, John N. Costello, Gordon Brandes, Lesley Ashburner, and Henry E. Birkinbine.

From Junior to Associate: Wilbur E. Fawcett.

The following resignations were read and accepted as of December 31, 1909: Edward B. Myers, H. R. White, John W. Townsend, Harry H. Cooke, Harry W. Jayne, J. Livingston Poultney, Joseph Johnson, Wm. C. Williamson, Herbert Hollick, J. Max Bernard, and Clark Dillenbeck.

It was moved that the regular meeting of the Club, falling due on January 1, 1910, be postponed until the following Tuesday, January 4th.

A letter from Mr. H. F. Sanville, Chairman of the Committee on Increase of Membership, recommending certain changes in the By-Laws, was read, and referred to a special committee, consisting of R. G. Develin, Chairman, J. O. Clarke, Wm. Easby, Jr., W. S. Twining, and H. F. Sanville, to report at the next meeting of the Board.

The rules for the government of the Board of Directors were referred to the Secretary for revision and presentation at the next meeting of the Board.

Following an informal discussion of the affairs of the Committee on House, it was moved that plans and estimates for changes in the location of the offices be obtained and submitted at the next Board meeting.

It was also moved that the House Committee be authorized to make changes in the lighting, provided the expense of such changes did not exceed $200.

The President appointed Mr. W. L. Plack an additional member of the Committee on House.

Special Meeting, December 18, 1909.—Present: President Dallett, Vice-Presidents Devereux, Easby, and Hess, Directors Clarke, Head, Quimby, Christie, Cochrane, Develin, Plack, Gwilliam, Mebus, Wood, the Secretary, and the Treasurer.

The following resignations were read and accepted as of December 31, 1909:

Active: E. M. Bassett, Francis R. Berlin, J. W. F. Blizard, Wm. H. Butler, Jr., H. D. Fischer, Caspar W. Haines, Chas. E. Machold, Edwin F. Miller, and Harry M. Platt.

Junior: Harry H. Appleton and Donald Graham.

The Committee on House presented its report on certain proposed changes in the Club-house, but action in the matter was deferred until after the first of the year.

The treasurer presented the monthly statement of the accountants, and reported on the present financial condition of the Club.

PROCEEDINGS
OF
# THE ENGINEERS' CLUB
OF PHILADELPHIA.
ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.



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## PRESIDENT'S ADDRESS.

WILLIAM P. DALLETT.

*Annual Meeting, February 5, 1910.*

FOLLOWING the time-honored custom inaugurated by the first President of this Club thirty-one years ago, it is my privilege and duty to address you at this time. As he fittingly called his address "the last chapter in the first volume of our history," so this will be the last chapter in the thirty-second volume.

It is a pleasure to congratulate the Club upon its thirty-two years of practically uninterrupted prosperity in its ever widening field of usefulness. There have, of course, been periodic depressions in the lines representing membership, finance, attendance, etc., but the general tendency of all these lines has been constantly upward.

The slight loss in membership during the past year has no doubt been in a measure due to the depression in general business, and also to the fact that the Club has just passed through its second summer of new Club life. Second summers in club, as well as in human life, can be considered as precarious periods, and the present healthy condition of the Club at the end of its second year in the enlarged sphere of Club life is certainly gratifying.

There has been a marked increase in the use of the Club-house at times other than on regular meeting nights. This increased interest of the members in the Club is showing results in the number of applications for membership that are being received, with every indication that a material growth may be expected during the coming year.

with economy, operated with economy, and designed to protect human life and health and to promote happiness by conserving human exertion and time.

In so far as the engineer succeeds in the promotion of conservation, just so far does he succeed in the carrying out of the ideals of his profession.

This is preëminently an age of mechanical power. Wherever we look we see it supplanting all forms of physical exertion. We need go back little more than a half century to find practically all the labor on the farm performed by human energy. The introduction of machinery operated by animal energy was a stride in the line of conservation.

The mowing machine, the churn, the thrashing machine, the planter, the cultivator, and the more complicated reaper and binder, all operated by animal energy, have rapidly supplanted the earlier and more laborious methods of performing the same work. These in turn are being supplanted by more efficient machines driven entirely by mechanical energy.

On the modern farm you will find that the gasoline engine has supplanted the treadpower and the sweep. The automobile has already supplanted the lighter vehicles, and is rapidly supplanting the heavier ones. All the minor chores of the farm are being done by some form of mechanical motor, and even house-cleaning is done by mechanical power.

We also find the horse-car of twenty years ago supplanted by the cable car, and it in turn supplanted by the electric car. The sailing vessel has practically been supplanted by the steam-propelled craft, be it the tramp steamer or the palatial liner attempting to cut a few hours off the already marvelously short trans-Atlantic trip.

Thirty years ago the streets of Philadelphia were entirely without electric lights, and when in 1883 forty-nine experimental lights were placed in Chestnut Street, the public press predicted total blindness of the coming generations on account of the brilliancy of electric light. In fact, twenty years ago there were barely 1000 electric street lights in the entire city, while to-day an accurate estimate would be indeed difficult to make and still harder to believe, the growth having been so rapid and enormous.

Mechanical refrigeration has practically supplanted the use of natural ice. Locomotives have increased in size from a few tons to over two hundred tons. Textile mills and other manufactures are

the method, the engineer will be the means, and the answer will be conservation.

Probably one of the most important events of the year, so far as Philadelphia is concerned, and one which passed so quietly that its occurrence was scarcely noted, was the completion of the Torresdale filter plant, with a daily capacity of 240,000,000 gallons of filtered water, sufficient for the entire city. The conservation in life and health due to the filtration of the water-supply cannot be measured in dollars and cents, but expenditures greatly in excess of those already made and contemplated would have been more than warranted by the results which the statistics have already indicated, and future statistics will no doubt disclose similar results. The expenditure for all the filtration plants, including that of Queen Lane, which is under construction, and the pumping plants and the extension of distributing and force mains, will approximate twenty-eight million dollars.

The elimination of grade crossings by the elevation or depression of roadbeds, of either steam or electric roads, makes for the conservation of human life by the reduction of the number of accidents and conserves the time of patrons by shortening the running schedule. To this end the city of Philadelphia and the Philadelphia and Reading Railway are at present carrying out a most substantial and gigantic operation in the elevation of the latter's roadbed. The masonry and concrete work of this improvement are well worthy of note.

The expansion of the high-pressure fire-protection system by the erection of a high-service pumping station at Sixth Street and Lehigh Avenue, and the installation of high-service fire mains through the mill district, is a work in the direction of conservation of fire losses which deserves commendation. The original high-pressure service installation at Delaware Avenue and Race Street has proved such a success in preventing conflagrations in the hazardous central district of the city that the extension above alluded to is more than warranted.

Recently interesting papers upon the Passyunk Avenue bridge, the Walnut Lane bridge (both in Philadelphia) and the Mulberry Street viaduct at Harrisburg, Pa., have been presented before the Club. The last two, in particular, exemplify one of the many artistic uses of concrete construction. The designers in both cases have succeeded in erecting lasting monuments, not only to their engineering ability, but also to their artistic appreciation of what is beautiful.

Passing note might be made that the year 1909 will always be marked as an epoch in aërial navigation. An immense amount of experimenting, performed by eminent scientists long prior to this, conclusively proved that heavier-than-air machines were possible. This year marks the popular achievement of actual flight, not by a single aviator, but by dozens, who have vied with each other in making records, only to be broken at the next contest. The dirigible balloon gives much promise as an engine of war.

The development of the automobile during the past year has been marked along all lines, especially in the development of heavy trucks for commercial use.

The marvelous growth of the cement industry is of particular interest to the engineer, having grown a hundredfold in the past fifteen years. In 1895 the output of the cement mills of the country was less than one million barrels, while the mills to-day have a capacity exceeding one hundred million barrels.

An event of international importance is the completion of the Trans-Andine Railway, connecting the National Railway of Chile with that of Argentina, crossing the Andes Mountains at an elevation of nearly 12,000 feet; when placed in operation, it will connect Beunos Aires with Valparaiso.

A further indication of the development of our sister republic in South America is the report that orders have been placed with American firms for two battleships of dimensions and design which will make them the most formidable war vessels afloat. The cost is said to be eleven million dollars each.

Probably no bureau in any department of the United States Government is doing better or truer conservation work than that which is being done by the Reclamation Service. While the popular idea may be that its work consists of building dams, canals, tunnels, and water-power plants for irrigation projects, a thorough investigation reveals the fact that its success is due as much to administration as to solving material engineering problems. Complicated questions concerning land and water rights have to be met, as well as those concerning power generation and distribution and the settlement and improvement of the reclaimed land. The high efficiency of the service should be a subject of pride throughout the engineering profession, particularly as it has been built up by civilian engineers and under civil-service regulations.

This bureau has just completed the Shoshone Dam, which has a

pany in financial difficulty, and confronted with the fact that the canal could not be built within the estimate. A change of plan was found necessary, and one involving a temporary lock was determined upon, with a summit level of 160 feet. The company, however, failed to place its bonds, and passed into the hands of a receiver in 1889.

Five years later, in 1894, the New Panama Canal Company was formed, and resumed operations on the canal, which was to have a summit level of 102 feet. Work was continued by this company until 1902, when, with as much diplomacy as was exhibited in the purchase of this Club-house, the United States Government purchased for forty million dollars what was originally held by the French company at one hundred and nine millions; the characteristic American bluff having been worked by the commission reporting to Congress the advisability of adopting the Nicaraguan route in preference to the Panama at the figure asked. There is no doubt that a figure considerably higher than this would have been a bargain, as there had been excavated by the first French company about seventy-two million cubic yards, and by the second French company ten million cubic yards; about one-half of this total excavation was of use in the canal now under construction. There seems to be a strange coincidence in the fact that as the Panama Railway was built by Americans after the failure of two French companies, so the United States Government is now completing the canal after two like failures.

Congress, in deciding upon the type of canal after receiving the reports of an appointed board of consulting engineers, wisely adopted the report of the minority. Possibly the personnel of this minority may have had its influence, for it was composed of five American engineers, while the majority report was signed by two Americans and five foreigners.

In addition to the personnel of the minority, the arguments in favor of the lock canal outweighed those for the sea-level canal, not only in point of economy in first cost and time of completion, but also in the methods adopted for controlling and absorbing the flow of the Chágres River at times of flood; and, further, from the facts that the dimensions of the canal prism on the lock type were much more generous and the channel nearly freed from curves, thus making navigation less difficult and more rapid, notwithstanding the delay incurred in passage through the locks. Moreover, tidal locks would

From this tabulation, it will be seen that the French excavations amount to about 14.6 per cent. of the total, the American excavations already performed about 46.4 per cent., and that 39 per cent. still remains to be done.

Outside of the magnitude of the constructive engineering, the most striking feature in connection with the construction of the canal has been the admirable sanitary conditions maintained throughout the canal zone, which converted this generally conceded pestilential district into one practically free from all usual tropical diseases. Perhaps nothing has contributed more largely to the apparent American success in prosecuting the work than this attention to the sanitary conditions, while the French failure may be largely attributed to a disregard of proper sanitation. It is interesting to note that in addition to looking after the sanitary welfare of the entire community, the Government carries on a most excellent subsistence department, polices the zone, administers justice, and looks after the recreation of the employees by providing club-houses equipped with billiard and pool tables, bowling alleys, reading-rooms, libraries, and assembly-rooms, all of which are evidently considered necessary to the healthful development of the proper "esprit de corps."

Fellow-members: In retiring from this office with which you have honored me, I wish to thank you for the cordial support you have given the administration, and the fraternal feeling that has always been extended to me personally. I bespeak for the coming officers an exhibition of the same loyalty, in which, I assure you, I shall join most heartily.

In 1867 a diamond was accidentally discovered in a South African village, on the banks of the Orange River. It weighed 23.5 karats (about 75 grains). In spite of much search, some months elapsed before more were found, but it was soon evident that an important supply could be obtained from the sands of the Orange and Vaal Rivers, and the usual "rush" began. Mining in these localities was industriously carried on. After some years of this method a diamond-bearing deposit of an entirely different character was found. The fact that garnets were generally found with diamonds in the river-beds led a local prospector to open up the soil of a farm in the Orange Free State in places in which he had noted the frequent occurrence of garnets. His ingenuity was soon rewarded by the discovery of a limited area yielding the precious minerals.

The conditions in this new mine were wholly different from those that had been anywhere else encountered in such mining. The locality was not alluvial, but a comparatively firm mixture of minerals, more or less igneous in their origin, filling a deep crater. The discovery was followed by others of the same type, and the world's supply of diamonds is now very largely derived from these South African deposits, termed "dry mines," to distinguish them from the alluvial localities. The craters are locally termed "pipes." They are of limited area (from ½ acre to several acres) and of unknown depth. One of them is now being worked at a depth of over 2000 feet.

The new feature, of course, gave rise to a new "rush." Owners of craters sold claims of a few square feet in area, and the exploiters began to dig, sieve, and wash the earth within the limits of their claims. Much confusion arose. Some, working faster than others, made narrow and deep excavations, causing collapse of neighboring banks. The area soon became so irregular that access to some claims became impossible. Legal interference was invoked for the purpose of maintaining roadways across the crater area, but it was only partially successful. The conditions were becoming intolerable, but finally the usual business methods of the present age were put in operation. Capitalists and promoters got control of many claims; finally a few choice spirits had all the important areas in their grasp, and at present the diamond-mining of South Africa is in the control of the De Beers Consolidated Mines, Limited, the names of Barney Barnato (actually Barney Isaacs) and Cecil Rhodes being especially prominent in the work of organization. Some mines are not directly

and at very high temperatures will take fire, burning simply with a glow, and produce, in a free air-supply, carbon dioxid. This determines the composition of the diamond as being carbon. Sometimes they contain enclosures of carbon dioxid under great pressure, and explode when even gently heated. True diamonds have been produced artificially, but only so minute as to be of no more than scientific interest.

No theory of the formation of natural diamonds has yet been offered which meets with general acceptance by geologists and mineralogists.

pelled vehicle they must, in addition, serve to transmit the torque of the motor to the road. This results in a radical change in the action of the tires on the road surface in addition to the change in their physical character.

There is, in addition to the vertical force due to the load, a horizontal force due to the motor, which tends to shear the surface of the road over the area of tire contact.

Considerable attention has been given to the varying value of this force, and it may be expressed as the sum of six terms:

1. A function of the weight of the machine, the friction on a driving-wheel, and the condition of the road surface.
2. The weight of the machine and the acceleration at any instant.
3. The air resistance, which involves the cross-section of the machine and the speed.
4. The weight of the machine and the grade.
5. The weight of the machine and the depth of momentary depressions in the road surface.
6. The weight of the machine, the speed, and the radius of the curves rounded.

The maximum value is, of course, attained when the tires begin to slip on the surface, and is equal to the weight on a driving-wheel multiplied by the coefficient of friction.

That this maximum value is frequently attained is proved by experiments, which show that the driving-wheels of a motor car constantly travel farther than the front wheels; when this occurs, as it constantly does, the rear tires, whose soft and generally slightly roughened surfaces are charged with minute particles of the rock dust from the road, act like a regular grindstone on the wearing surface.

The flexible nature of the rubber surface gives it a grip on the finer stone particles, so that the horizontal shearing force tends to sweep them from the surface voids, dropping them a few inches in the rear, where they are distributed over the road and adjoining property by the air-currents set up by rapid movement of the car.

There are a number of other actions which no doubt contribute to this result; such as the suction effect produced in the rapid passage of the soft tire over the road, the longitudinal stretching of that portion of the tire surface in contact with the road due to the rapidly changing value of the tangential force during the time that any point of the tire is in contact with the road, and the change in posi-

very unstable, as it is dependent upon very slight changes in the moisture content.

Surface coatings of oils and tars were then tried. These materials were applied either directly on the road, or as emulsions with water to facilitate their application and absorption in the road.

These surface treatments have undoubtedly been of considerable benefit under certain circumstances, both as allaying the dust nuisance and in preserving to some extent the continuity of the surface.

It must be remembered that when such materials as oil or tar are applied they usually destroy, to a very considerable extent, the natural cementing or compacting quality of the rock dust. This cementing quality must be replaced by the binder in the oils, so that their value is dependent upon the amount and strength of the binder which they actually bring into active action in the surface. In some of the preparations that have been tried this resultant binder is practically worthless, because the maker fails to realize what is required of a road binder.

The use of a larger quantity of a fairly heavy tar or oil, followed by an application of fine crushed stone or sand, came as a development of the purely surface treatments. In this method the finer dust and stone particles are removed, exposing the ¾-inch and larger stone. The binder is then applied hot, and thorough contact with the surface insured either by brooming or spraying it under pressure. The stone, screenings, or sand is then spread evenly and the road rolled.

The surface dressing absorbs the surplus binder that is not taken up by the road, and on rolling forms a new surface, of thoroughly bound particles, that is waterproof and will resist ordinary motor traffic. The thickness of this layer varies from ¼ to ¾ inch, according to circumstances, and lasts from one to two years, depending upon the materials, traffic, and the skill in application.

This form of treatment has been extensively used in England. The statistics collected by the Road Improvement Association for 1908 showed that 1630 miles of equivalent 21-foot road were treated as follows:

| | |
|---|---|
| With tar macadam and similar processes... | 52 miles = 3.2% |
| With penetration and similar processes..... | 44 miles = 2.7% |
| With surface treatment.................... | 1290 miles = 79.1% |
| With emulsions, calcium chloride, etc. ..... | 244 miles = 15.0% |

The treatment is fairly cheap and easy of application, particularly

This stone should, if possible, be graded slightly, that is, sizes should be from 1½ inches to ¾ inch. As the rolling is started, a small quantity of ¾-inch stone should be spread evenly ahead of the roller so that the whole layer may be thoroughly keyed up from the bottom, and the larger surface voids filled with ¾-inch stone. The quantity of ¾-inch stone used will run from 15 to 20 per cent. The rolling should continue until a firm, compact surface is obtained, free from waves, but should not be carried on after the edges of the larger stones (particularly with limestone) begin to round off. When this layer is properly rolled and thoroughly dry, the binder may be applied.

The uniform distribution of the binder and its temperature are quite as important as the preparation of the stone. In order that the binder shall properly coat all the stone and fill the smaller voids, thus giving a well-bound aggregate, it is very important that its consistency at the time of its application should bear a proper relation to the temperature of the stone.

If the binder is applied too cool, it chills on the surface and does not flow freely into the smaller voids, and thus coat the lower stone, and an excess will have to be used to even cover the surface.

If, on the other hand, it is too fluid, it runs directly through the upper course of stone without leaving a coating of the proper thickness, and collects in pools on the binder of the lower course, where it rises in places to the surface, forming soft spots in summer. There is also a tendency to apply an insufficient quantity, owing to the ease with which it flows over the surface stone.

The subconscious effect of the fluidity on the man who is applying the compound is very interesting, as the amount applied per square yard can be varied quite widely by changing the temperature without the laborer being aware of it.

That the compound should be applied uniformly is, of course, self-evident, and there are a number of schemes for doing this. The earliest was the use of ordinary coal-scuttles, the flat lip delivering a fairly even ribbon of binder on the road. Garden sprinklers with either a specially punched rose or a thin, vertical, fan-shaped nozzle have been used on small stretches quite successfully. Light skeleton frames enclosing one or two square yards of surface have been used as a guide to determine the proper amount to be applied.

On larger areas iron tank wagons are usually employed to heat the binder, and it is applied through a hose with a flat, fan-shaped nozzle. This method has been improved recently by applying pressure from

This is diluted with water and sprinkled on the road from an ordinary sprinkling cart, so that it is extremely easy of application. On drying, it yields a very hard and compact surface that is quite free from dust, and that seems to resist ordinary traffic very well. The length of time that it remains effective depends somewhat on the rainfall (as it is soluble in water) and on the traffic, but on roads not subjected to heavy motor traffic, it will apparently last through a season.

The other material is known as "Rocmac," and is said to be a compound having sodium silicate as a base, and sugar, mixed with powdered calcium carbonate, a pure form of limestone.

This mixture is applied to the depth of about an inch over the old surface, and the stone for the top course spread over it. The surface is rolled until the binder has filled the voids and rises on the surface. It is then swept evenly over the road, and a thin coating of limestone dust is sprinkled over it to protect it while setting up, which requires from two to six days. The compound combines chemically with the limestone, forming a cement, which serves to bind the wearing surface into a compact mass.

***The mixing method:*** In order to secure more complete control over the distribution of the binder, and a more compact stone mixture in the wearing surface, considerable attention has been devoted to the mixing method of construction.

This is but a development of the earlier form of tar macadam that has been used with varying degrees of success during the past fifty years. With the increase in our knowledge of the properties of binders and their preparation, and the proper working conditions for their use, which has resulted from the experimental work done both here and abroad during the past ten years, this form of construction has been brought very much to the fore. Already two State road authorities, Rhode Island and New Jersey, have decided to use it exclusively.

With this method the foundation course need not be filled, as in the penetration method, but it should be thoroughly compacted. In resurfacing old work after the surface has been brought to crown, some form of bond should be provided between the old and new work. This is best secured by rolling in an even one-stone layer of 2½-inch stone.

A light sprinkling of tar oil is of considerable advantage before spreading the top course, as it penetrates the dust on the surface of

⅛ inch in size, and after that has been thoroughly packed, applying a portion of screenings containing a considerable amount of dust.

In regard to concrete: We have tried the concrete road. We tried that once by reason of a cloudburst which tore off a section of our road, leaving the telford exposed, and to meet such a condition, should it occur again, we made a mixture of 1 : 3 : 5 concrete and applied it on top of the telford to the depth of 4 inches, rolling and tamping it in until the slush came on top, and then applying ¼-inch to ¾-inch rock screenings free from dust on top, tamping these until about half the stone was embedded in the slush, and finally covering the surface with a screening containing 5 per cent. of dust. On one portion of the road we put in expansion joints and in another section we put in none. The section in which no expansion joints were placed is to-day the better section of the two. We have since put in several sections of that kind of concrete road to overcome the washing by floods or high water.

I do not know that I have very much more to say in regard to this subject; it is largely a matter of experiment, and we are trying to learn. We have several sections of road put down in the way I have described, and we are waiting until the winter is over to ascertain how they have stood up.

We have used the Amiesite method, and so far have obtained good results with that mixture.

We have also used a preparation made by the Commonwealth Construction Company, a mixture which they invented and put down for the Department on a section of road near Harrisburg. On top they put an inch covering of sand and asphaltic binder, making practically an asphalt finished road. We cannot tell, however, until the spring, just what the winter's use of the road will show.

We tried the brick pavement in some sections. Our reason for trying it was because it was practically the cheapest material we could use in the section where it was laid. It has so far given good results. It makes a rigid paving and fit for heavy wagon and automobile traffic, but it is possible that the farmers and others who want to drive fast horses over it will eventually find fault with it.

I would like to ask Mr. Fulweiler, in regard to the brick road he showed, how was the brick retained in place? What sort of curbing was used?

Mr. Fulweiler.—There was a concrete curb on each side, and the bricks were laid on a sand cushion and grouted with cement.

Mr. Hunter.—We have used concrete curbing, but in nearly every case we have made it flush with the road. We have also used a gravel foundation and the sand cushion, and have obtained very good results from that method.

S. M. Swaab.—I would like to ask Mr. Hunter what kind of expansion joint is used in concrete road work?

Mr. Hunter.—It is made of tar-paper, ¼ to ½ inch thick, but even a one-eighth joint is entirely too wide, as at the joints the concrete chips off unless the concrete is covered with screenings at the joints; it is apt to be chipped off by the caulks on the horses' shoes.

Benj. Franklin.—I would like to ask Mr. Hunter if he thinks, if automobile traffic was regulated to a speed of twenty miles an hour, ordinary telford would be considered satisfactory?

Mr. Hunter.—An automobile running at that speed would not destroy the road. Of course, the injury from automobile traffic is more than from ordinary horse traffic. It is the heavy machines running at high speed that do the damage.

motor truck and other motor-driven commercial vehicles will be used here as they are in England, as their use is an important factor in reducing costs. The great difficulty is the fact that they cannot climb much of a grade without rubber tires, or some form of non-skidding device. They are now trying to construct them with a drive on all four wheels in order to use the smooth steel tire. Their destructive action on roads is caused by the grids on the wheels shearing the surface whenever the top car turns from a direct line. This digging action has caused considerable damage already to the English roads.

With regard to costs, there have been a number of articles published by some French engineers in "Les Annales des Ponts et Chausses," in which curves are shown of the allowable cost of treatment based on the traffic the road has to bear. In considering these curves for a great many roads, the surface treatment seems to be very economical, but it must be remembered that in England and on the Continent they use machines for spraying the tar, and thus apply only a very small amount per square yard, so that their cost works out to from 1 to 3 cents per square yard, which is less than half of what it is here.

Mr. Boorman.—Has Mr. Fulweiler any record of the length of time that the Nottingham road was in good condition? In reference to my 1849 road, I have record, that M. Leon Malo located that road in Travers in 1866, and found it was then in comparatively good condition. I hardly think that the tar drippings would have given an equally satisfactory bond to the road or walk on which they fell.

Mr. Fulweiler.—I cannot tell you anything about that road, except from the printed record, but there is a tar road built up in New Hampshire, in practically the same way as the walk referred to, with tar from a gas works, which has been down about twenty-eight years, and is still giving pretty good service. I think the road Mr. Boorman referred to was down about nineteen years.

ment of commercial processes for the production of ozone. The well-known germicidal properties of this oxygen compound, coupled with the fact that its end-product is ordinary atmospheric oxygen, make the process an ideal one from a chemical and physiological point of view. Commercially, it has always been hampered by the relative high cost of production, by mechanical deficiencies in the machinery necessary for such production, and by certain physical difficulties attendant upon the introduction of the ozone into the water. Therefore, despite the fact that progress in the ozonization of water has been consistent and quite rapid, yet the use of ozone in water disinfection has not become general. It must be particularly noted, however, that the deficiencies of this process are purely mechanical, and that the work of investigation which is going on in many parts of the world may reasonably be expected eventually to develop a process as successful commercially as it is ideal from purely sanitary considerations.

Quite early in the history of the chemical disinfection of water the possibilities of chlorin compounds were recognized. Electrolytic processes for the manufacture of these compounds were developed as early as in 1889, when Webster in England and Woolf in this country attempted the use of electrolyzed sea-water solutions in disinfection work of one kind or another. Here again mechanical difficulties were met with which, combined with the fairly high cost of production, prevented the general adoption of these methods. The commercial production of calcium hypochlorite or bleaching powder had in the meantime been developed to so high a degree of efficiency, owing to the great commercial demand for this product, that sanitarians soon had at their command an extremely efficient disinfectant which could be obtained in any desired quantity at very moderate cost. Attention therefore was early directed to the possibilities of this commercial product, particularly in connection with sewage disinfection. As early as 1854, the Royal Sewage Commission of Great Britain recommended the use of this substance in deodorizing the sewage of London. In 1885 the Special Committee of the American Public Health Association carried out an exhaustive study of all available disinfecting materials, and found that hypochlorites in general were the most efficient substance that could be used, cost being considered. In Germany, at the Hamburg Hygienic Institute, the work of Proskauer and Elsner in 1897, and later of Dunbar and his associates in 1904 and 1905, demonstrated anew the

have been confirmed, and for the first time in the history of chemical disinfection, it has been amply demonstrated that sewage may be thoroughly disinfected at a cost which is not disproportionate to the cost of other purification processes.

Briefly, then, this is the history of the development of chemical disinfection. At the present time the most serious problem is not how to disinfect sewage or water, but rather under what conditions such disinfection is called for, just what the process accomplishes and under what amount of supervision it must be carried out. There is grave danger that, through ignorance of the essential aims and actual accomplishments of this process, it will be misused or employed in situations where its use is uncalled for. Therefore this opportunity to explain the particular work which the process may be expected to accomplish, the peculiar conditions under which it may be properly applied, and its severe limitations, as a general method of sewage treatment, is especially welcome. It must be pointed out at the very outset, and will be reiterated throughout the course of this paper, that the chemical disinfection of sewage or of water is not a panacea. Except under strictly limited and peculiar local conditions it is not even a substitute for other purification methods. In general, it may best be described as an "adjunct," or, to use a term familiar to engineers, "a factor of safety." To the extension and development of this idea, and to a discussion of the actual place of disinfection in sewage and water work, these remarks will be chiefly addressed.

The recent revival of active interest in the possibility of chemical disinfection took place, first, in the field of sewage disposal, and later spread to water purification. It may be well to maintain this order of development, and to consider first the chemical disinfection of sewage and of sewage filter effluents.

## Disinfection of Sewage.

Sewage consists of about 999 parts of pure water and 1 part of impurity, about one-half of which is organic impurity and bacterial life. Sewage disposal deals with this five one-hundredths per cent. A perfect process of sewage disposal may be defined as one which totally removes and finally oxidizes to a mineral form this very small proportion of organic matter. The slow sand filter, developed to its highest degree of efficiency, can be relied upon under specially favorable conditions to practically accomplish this result. It is possible to produce by such means a water fit for domestic purposes.

stream is swift and the dilution large, or if the discharge be made into rapidly moving tidal currents, this nuisance will not occur, and special treatment for its abatement will be unnecessary and unwise. Under reverse conditions of discharge into slowly moving streams, particularly into streams which are dammed, or bodies of water which are shallow and do not possess strong tidal currents, the possibility of deposit upon the bottom is one which must be dealt with, and the removal of suspended matter from the sewage must be accomplished to a greater or less degree.

The second kind of nuisance is that which results from the putrescible character of sewage, regardless of whether the organic matter is suspended or in true solution. This is the property of sewage matter by which it robs a stream of its available oxygen, and consequently of its power of self-purification. Under these conditions fish life is destroyed, noxious odors arise from the water, and the stream becomes virtually an open sewer rather than merely a polluted water. The line between these two conditions is a distinct one. The capacity of any stream to absorb sewage and maintain its own aëration is limited and calculable. If this capacity is exhausted, a very definite change in the character of the water occurs and the conditions above outlined result. The treatment of these conditions must be very different from that outlined in the first case. The question of suspended matter may or may not be a factor, but in this case the organic matter must first be oxidized and rendered stable or non-putrescible. The process of oxidation may go on independently of, or in connection with, any other processes, according as one or more of these classes of nuisances is possible.

The third special class of nuisance, and one which refers to public health rather than to public convenience, is the ever present possibility that pathogenic bacteria may be contained in the sewage. The extent of this danger need not be argued, nor is it desirable at this time to take up the somewhat debatable question of the efficiency of our ordinary sewage purification processes in destroying such bacteria. Somewhat divided opinions upon this question are held. The most exhaustive study of the problem that has yet been made was carried out by Houston under the auspices of the Royal Sewage Commission of Great Britain, as a result of which it was concluded that "the biological processes at work in the filters were not strongly inimical, if hostile at all, to the viability of pathogenic germs." It is the speaker's opinion, based upon all the available

partially; a residue of carbonate of lime and an excess of free lime remaining in the tank as a white sludge. In practice it is desirable at larger works to keep this mixture stirred up and to discharge the sludge with the solution; at smaller works economy indicates the use of the clear solution and the disposal of the lime sludge in a convenient manner. To the layman one of the most striking features of this process is the relatively small amount of disinfectant necessary. For crude sewage an amount of so-called "available chlorin" equivalent to about five parts per million parts of sewage, which amounts to about 125 pounds of bleaching powder per million gallons, suffices. Upon the present market price of $25 per ton or less, it will be seen that the cost of bleaching powder necessary will be in the neighborhood of $1.70 per million gallons of sewage disinfected. By the use of the quantity indicated, disinfection is accomplished within a very few minutes, and storage periods of not over thirty minutes are ample. Sewage stronger than the average American sewage would require somewhat larger amounts than these indicated, but twice the quantity probably represents the maximum. For partially purified effluents, such as those resulting from trickling filters, lesser quantities are sufficient. At Baltimore three parts per million of available chlorin, or 75 pounds of bleaching powder per million gallons, were found effective in the disinfection of the trickling filter effluent. At Boston satisfactory disinfection of a similar effluent was accomplished through a period of six months by the application of three and a half parts of available chlorin. Effluents of a higher degree of purity can be disinfected with corresponding smaller amounts. The total cost of the processes, including interest charges and depreciation upon the necessary fixtures, labor, and other items, will range from $1.00 or less in the case of effluents to about $3.00 in the case of crude sewages. These details are given in the accompanying table. The results, which have been described as satisfactory, are numerically expressed by removals of the total bacteria, averaging 97 per cent. in the case of effluents and 99 per cent. or more in the case of crude sewage. In the former case the combined efficiency of the filter and the disinfection will bring the figure up to 99 per cent. or more. Special studies have also been made in this connection to show the probable effect upon typhoid fever germs as compared with the effect upon the total bacterial content. The indication has been that the former are affected to fully as great an extent as the latter. They are probably more completely removed.

is certainly true that under certain circumstances the chemical disinfection of water may be used to great advantage. As in the case of sewage, so also in the case of water, special consideration must be given to the primary needs of the situation. Disinfection merely kills the germs; if this is all that is required, then disinfection is indicated; if the removal of organic matter from a water seriously polluted with sewage is deemed advisable, then some other process must be employed. If that process is efficient also in the removal of germs, disinfection is uncalled for. If that process, on the other hand, is insufficient, or if economy indicates that it may purposely be made insufficient,—through the use of high rates of filtration, for example,—then disinfection may be advantageously employed to supplement the imperfect process. The two great fields which are open to water disinfection are the treatment of a very slightly or only occasionally polluted supply by disinfection alone, and the treatment of a more seriously polluted supply by the present methods at highly increased rates and by subsequent disinfection. In the latter case disinfection will be found a valuable adjunct to overloaded mechanical filters. The limiting rates of operation on slow sand filters are determined largely by the organic content of the water and by consequent economy in the expensive cleaning processes. The limiting rates on mechanical filters, on the contrary, are practically determined by the necessity for obtaining bacterial purification. Therefore it is especially with reference to this latter type that disinfection will be found important.

Although, as has already been indicated, the chemical disinfection of water has been practised from time to time at various places, the first notably successful plant in this country at least, and the one which is directly responsible for the present favorable consideration which this process has acquired, was constructed and operated early in 1908 by Mr. George A. Johnson, of New York city, at the Chicago stockyards. At this plant the highly polluted water of Bubbly Creek was treated first by chemical precipitation and then by means of bleaching powder. The results of this undertaking were highly satisfactory. Later Hering & Fuller, of New York city, of which firm Mr. Johnson is a member, were called upon to construct at Boonton, New Jersey, on the Jersey City water-supply, a plant for the complete disinfection of forty million gallons of water daily. This plant, which has been in operation since September, 1908, has been so fully described in various papers by Dr. Leal, who is primarily

operation, should in every case be submitted to expert judgment. In addition, the routine operation of the plant should be safeguarded in such a way that the possibility of mistakes should be minimized. As little responsibility and as little chance to go wrong as possible should be left to the operator. In other words, the operation should be made as nearly fool-proof as possible. With these safeguards properly applied, and under the conditions which have been outlined, it can safely be said that a new epoch in water purification methods has begun, and that the methods developed and introduced by Dr. Leal and Mr. Fuller, and especially by Mr. Johnson, have already established their rightful place in the ever growing field of water purification.

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## DISCUSSION.

F. HERBERT SNOW (Harrisburg).—As you know, there is a Pennsylvania law enacted at the last legislative gathering which prohibits the use of alum and copper compounds in food-stuffs. It may be found under one of the sections of the Pure Food Act. The question of whether this law can be extended to apply to treated waters supplied for public uses is a mooted one. It has received some minor consideration, and was the subject of particular inquiry at the time the bill was before the legislative committee. I believe it was generally accepted that the bill if it became a law would not be applicable to mechanical filtration plants where the purification of the water is accomplished in part by the introduction

been operating night and day, twenty-four hours every day, Sundays included, an experimental plant that follows as nearly as possible the working conditions that will obtain in a full-sized plant. Various processes have been under observation and almost everything that has been advocated has been tried. A great many things have been eliminated after trial, and it only remains to complete the full cycle of seasons to determine certain fluctuations and certain other factors which may be applied in the design and construction of a full-sized plant, as far as the local conditions are concerned. But these factors cannot be taken as applying to other conditions unless the character of the sewage and the other problems that arise are similar.

Something has been done in the way of disinfection, principally in finding out mechanical difficulties. We have not yet determined the minimum amount of bleach that should be added to obtain satisfactory results, but are hopeful of accomplishing this in a short time. As Professor Phelps has said, "there are certain difficulties which arise in the application of bleach through small orifices, due to the deposits of a calcareous nature in the receptacle, appearing as a white sludge and almost in quantity as much as the original bleach," if I am quoting him correctly. We found this to be true, and made no less than five different devices to overcome it, and owing to the persistence and ingenuity of the engineer in charge of the testing plant, I feel sure he has accomplished it. I am led to make this statement because a member of one of the largest consulting engineering firms in this country was very glad to accept the suggestion and apply it to one of the plants of his own design. We find that bleach attacks brass, iron, platinum, and other metals, and corrodes them very quickly. Even lead, which is attacked less than other metals, suffers in time. This is an important thing in a large plant, and it is hard to determine just what should be used. Vulcanized rubber and glass seem to resist the corrosive qualities, and we have had some little success with fiber.

I feel sure, gentlemen, that Professor Phelps, in his work, has conferred a distinct benefit upon the engineering profession and upon the general public of this country. I am led to this statement not only from the perusal of his articles and having become somewhat familiar with his experiments, but from the view that has been taken by others. I find, in reading foreign periodicals, that the English search with the greatest avidity for anything that comes from his pen, and his writings are spread broadcast throughout the kingdom of Great Britain. I think as Americans we should look with pride on an achievement of this character.

While the modern sewage problem was conceived by an Englishman, it was not until the Massachusetts State Board of Health took up the question and investigated it systematically and made experiments to see what could be done under varying conditions that it was reduced to a commercial basis. The results of those experiments have been gratifying, although on such a small scale. It has been said, however, that if they had a small filter about the size of the secretary's table, they could write a book about it about twice as large as the filter.

Nevertheless our English cousins have taken these experiments of the Massachusetts Board and backed them with millions of dollars to carry out those experiments on a large scale, and to-day all honor is given to their American cousins who have carried out these investigations.

material acts so strenuously on metals, even attacking platinum, it behooves us to think that there may be some serious danger in its use.

The prejudice against alum is not based on its use, but on its abuse. The same may be said of the use and abuse of bleach. This objection has always been made and will always exist unless it can be proved that an excess, however great, of the chemical cannot do any harm.

The study of the chemical purification of water deserves our closest attention. It should not be resorted to just to help a filter, as is the case when alum is used with so-called mechanical filters. Chemicals should be selected to purify the water independently of filtration and as if no filter whatsoever were to be used. We ought to spend our money on that which is necessary, namely, the material which does the work, and not in accessories.

There is no reason to limit ourselves to alum or bleach; you have the whole gamut of chemicals from which to choose. Suit the chemical to the particular water or the particular sewage to be treated. Lime, for instance, has been used in sewage purification abroad for a very long time, and it is still used in many places because it is safe and cheap. One of the objections urged against the use of lime in sewage treatment is that it makes a great deal of sludge. But lime plus sludge, if collected, would make a pretty good fertilizer.

One may perhaps not be justified in opposing the use of bleach as a disinfectant for sewage, because the treated sewage is mixed with a large volume of water and there is probably not enough of the bleach left to be appreciable. But I cannot conceive its satisfactory use for drinking water. A small quantity of the chlorin gas in the water passing through filters day after day must ultimately leave traces of the sand, which may give a bad taste to the filtered water long after the chemical has ceased to be added to the applied water.

The subject is well worth being studied by chemical engineers. Do not think that bleach or alum are the only available chemicals. Select the chemical that will do the work in a perfect manner. When entering upon the consideration of a problem of this kind, first ask: Is it wanted? Can it be done? Last of all, How much will it cost? If you put the last question first, you will never make any progress.

We are very much indebted to Professor Phelps for having brought the matter before us this evening. If disinfectants are necessary for water or sewage, they should not be added in the dark, but in broad daylight; not with an apology, but because they do the right kind of work and do it safely.

Mr. Phelps.—Replying to Mr. Maignen's question about the odor, I may say that the odor is a very serious matter to be dealt with. If we get too much bleach, we get an odor anyway. If there is too much organic matter, we are pretty sure to get the odor if we put in the bleach before it goes to the filter. It is not a chlorin odor; it is what we call a vegetable odor. We get around the difficulty by adding the bleach after filtration, and I think that is, on the whole, the best place to add it.

M. R. Pugh.—I would like to ask Professor Phelps whether he has made any investigation as to the effect of bleach on sewage before entering the bacteria beds. I believe that Dr. Dunbar has done some work in that direction in which he found it did not have an injurious effect on the bacterial action, and there were cases in which he seemed to think that an application of bleach before it went

# ANNUAL REPORT OF THE BOARD OF DIRECTORS,

**For the Fiscal Year 1909.**

January 29, 1910.

To the Members of The Engineers' Club of Philadelphia:

The Board of Directors hereby presents its report for the year ending December 31, 1909, as follows:

Eighteen stated and two adjourned meetings of the Club were held, at which the maximum attendance was one hundred and seventy-nine, and the average one hundred and twenty, a decrease in average attendance of twenty-two members compared with 1908, and an increase of thirty-four compared with 1907. The adjourned meetings were not included in computing the average attendance, as they were called to discuss proposed amendments to the By-Laws, and no papers were presented.

Ten stated, one adjourned, and eleven special meetings of the Board of Directors were held. The summary of membership on December 31, 1909, compared with the summary of December 31, 1908, is as follows:

| Class. | 1908. | | | 1909. | | |
|---|---|---|---|---|---|---|
| | Resident. | Non-Resident. | Total. | Resident. | Non-Resident. | Total. |
| Honorary | 1 | 3 | 4 | 2 | 2 | 4 |
| Active | 442 | 103 | 545 | 411 | 97 | 508 |
| Associate | 52 | 2 | 54 | 51 | 2 | 53 |
| Junior | 38 | 4 | 42 | 50 | 9 | 59 |
| | 533 | 112 | 645 | 514 | 110 | 624 |

Nineteen active, ten associate and thirty-five junior members were elected; one active member was transferred to the honorary grade; one associate to the active grade; eleven juniors to the active grade, and one junior to the associate grade; one honorary and five active members died; thirty-nine active, nine associate, and five junior members resigned; twenty-five active, two associate, and three junior members were dropped from the rolls, and two active members were reinstated to membership.

The report of 1908 was incorrect, in that two resident junior members were omitted. This number, therefore, should read forty, instead of thirty-eight, and the total should be six hundred and forty-seven, instead of six hundred and forty-five.

The record of deaths is:

Wm. Price Craighill, Honorary Member, died August 18, 1909.
Frederick Stamm, Active Member, died March 1, 1908.

paper of the evening, on "The Sanitary Control of Filter Plants," by Mr. F. D. West, chemist in charge of the plant, but the attendance was affected by very unfavorable weather conditions.

A reception, held April 30th, for the purpose of giving the ladies an opportunity of inspecting the Club-house, was attended by over three hundred members and guests; and a very successful vaudeville smoker, on November 12th, had an attendance of about two hundred and thirty. The expense of both functions was met by subscriptions from the members of the Club, and a small balance in the reception account was turned into the general fund of the Club. The smoker account also showed a small credit balance, but this was used to defray expenses of the Club nights, held the latter part of the year.

The Junior Section held eight meetings, at which the maximum attendance was thirty-one and the average twenty-one; or exactly the same as the average attendance of the seven meetings held last year.

The following papers were presented before the Junior Section:

| | | | |
|---|---|---|---|
| January | 16. | "The Organization of the Bureau of Surveys, Philadelphia." | E. J. Dauner. |
| February | 15. | "Concrete Construction." | L. R. Ferguson. |
| March | 15. | "The Development of the Water Turbine." | F. H. Rogers. |
| May | 10. | "Building a Brick Gas Holder Tank." | Alfred Weeks (Visitor). |
| June | 14. | "Manufacture of Portland Cement." | Richard L. Humphrey (Active Member). |
| October | 11. | "Making and Placing of Concrete Piling." | R. P. Raynsford (Visitor). |
| November | 15. | "Development of the Locomotive." | Stanley G. Child (Active Member). |
| December | 13. | "Relationship Existing Between Engineer and Employer or Client." | John W. Brassington (Visitor). |

In addition to the presentation of papers, the current numbers of the principal technical papers are reviewed at the meetings of the Junior Section. The section has a regular Committee on Inspection, and the list of trips follows:

| | | |
|---|---|---|
| March | 6. | Pencoyd. |
| April | 30. | Delaware Avenue Power Plant of the Philadelphia Rapid Transit Company. |
| June | 12. | Penn Allen Portland Cement Plant. |
| November | 20. | Victor Talking Machine Company's Plant, Camden, N. J. |

On June 15th Mr. Redding, manager of the Club, resigned, and Mr. Mish, a non-member, was appointed to the position, which he retained until the first of December, when the House Committee decided to take over the management of the Club-house. On December 1st the House Committee cancelled the contract with the caterer for the operation of the restaurant and appointed a steward to take charge of the restaurant. The improvement in the service has been very marked, and it is believed that the change will be a decided benefit to the Club.

The lighting fixtures have been changed and the lighting rearranged so as to reduce the cost and increase the efficiency of the lighting.

| | | |
|---|---|---|
| Brought forward | | $76,703.37 |
| Accrued interest, first mortgage | 1,080.00 | |
| Accrued interest, second mortage bonds | 1,730.00 | |
| | | 2,810.00 |
| Reserve for bond redemption | | 3,120.14 |
| Christmas fund | | 44.50 |
| Surplus as of January 1, 1909 | 5,621.28 | |
| Less loss for year as per statement of Income and Expenses | 2,305.71 | |
| | | 3,315.57 |
| Total liabilities | | $85,993.58 |

## STATEMENT OF INCOME AND EXPENSE.

Year ending December 31, 1909.

### EXPENSES.

| | | |
|---|---|---|
| *Salaries and Wages:* | | |
| House salaries and wages | $3,321.39 | |
| Secretary's office salaries and wages | 808.40 | |
| Treasurer's office salaries and wages | 1,466.35 | |
| Restaurant salaries and wages | 316.42 | |
| Total salaries and wages | | $5,912.56 |
| *Expense:* | | |
| House expense | $1,344.88 | |
| Secretary's office expense | 267.38 | |
| Treasurer's office expense | 258.72 | |
| Total expense | | 1,870.98 |
| *Publications:* | | |
| "Proceedings" publishing | $1,358.57 | |
| Directory advertising | 51.30 | |
| Directory publishing | 357.85 | |
| Total publications | | 1,767.72 |
| *Miscellaneous:* | | |
| Gas and electric light | $1,426.10 | |
| Telephones | 136.14 | |
| By-laws revision | 72.75 | |
| Club luncheons | 459.50 | |
| Meetings | 514.57 | |
| Membership Committee | 130.18 | |
| Reception Committee | 301.41 | |
| Pool subscription | 77.50 | |
| Smoker | 234.30 | |
| Billiards and pool repairs | 62.88 | |
| Taxes and water rent | 945.75 | |
| Insurance | 140.16 | |
| State tax on bonds | 120.00 | |
| Badges | 99.00 | |
| Reprints | 43.25 | |
| Total miscellaneous expense | | 4,763.49 |
| *Interest and Discount:* | | |
| Interest on first mortgage | $2,160.00 | |
| Interest on second mortgage bonds | 1,420.49 | |
| Discount on notes | 82.00 | |
| | | 3,662.49 |
| Carried forward | | $17,977.24 |

| | |
|---|---|
| Brought forward | $23,722 06 |
| Suspense | 46.27 |
| Total Income Year Ending December 31, 1909 | $23,768.33 |
| Total Expenses | 26,074.04 |
| Loss Year Ending December 31, 1909 | $2,305.71 |

Respectfully submitted,

H. E. Ehlers,
*Treasurer.*

The above report has been prepared by the accountants employed by the Club. The auditors have examined accounts taken at random, and believe that the report as set forth above is correct. The bank balances are correct.

W. B. Riegner,
C. H. Ott,
D. Robert Yarnall,
*Auditors.*

The following is the report of the Trustees of the Bond Redemption Fund:

January 8, 1910.

*Second Annual Report of the Trustees of the Bond Redemption Fund, being a statement of business for the year 1909.*

| 1909. | | Receipts. | | |
|---|---|---|---|---|
| January | 12. | Balance | $307.11 | |
| January | 12. | Coupons | 15.00 | |
| January | 30. | Initiation fees | 110.00 | |
| February | 15. | Initiation fees | 135.00 | |
| March | 23. | Initiation fees | 150.00 | |
| April | 30. | Initiation fees | 155.00 | |
| April | 30. | Coupons | 25.00 | |
| May | 3. | Initiation fees | 85.00 | |
| May | 3. | Coupons | 5.00 | |
| June | 30. | Initiation fees | 15.00 | |
| October | 13. | Initiation fees | 75.00 | |
| November | 20. | Initiation fees | 230.00 | |
| December | 15. | Initiation fees | 35.00 | |
| December | 31. | Interest on deposit | 3.04 | |
| December | 31. | Coupons due 1-1-10 | 172.50 | |
| | | | | $1,517.65 |
| | | Expenditures. | | |
| January | 12. | Bonds | $300.00 | |
| January | 12. | Accrued Interest | 15.00 | |
| April | 23. | Bonds | 500.00 | |
| April | 23. | Accrued Interest | 32.74 | |
| May | 6. | Bonds | 100.00 | |
| May | 6. | Accrued Interest | 6.77 | |
| June | 12. | Box Rent | 3.00 | |
| | | | | 957.51 |
| | | Balance | | $560.14 |

# ABSTRACT OF MINUTES OF THE CLUB.

REGULAR MEETING, January 4, 1910.—The meeting was called to order by the President at 8.35 P. M., with 88 members and visitors in attendance. The minutes of the Business Meeting of December 18th were approved as printed in abstract.

Mr. W. H. Fulweiler, Active Member, presented the paper of the evening, entitled, "The Destructive Effect of Motor Traffic on Road Surfaces, and Methods of Construction to Prevent It." Messrs. J. W. Hunter, T. H. Boorman, S. M. Swaab, Benjamin Franklin, C. P. Birkinbine, J. O. Clarke, J. C. Wilson, E. M. Nichols and others participated in the discussion.

The meeting adjourned at 10.30 P. M.

BUSINESS MEETING, January 15, 1910.—The meeting was called to order by the President at 8.35 P. M., with 119 members and visitors in attendance. The minutes of the regular meeting of January 5th were approved as printed in abstract.

Following the report of the Tellers, the President declared the following elected to membership: Active, Rodney D. Allen, R. Ruliph M. Carpenter, Irenee du-Pont, Henry E. Hayward, John E. Hubbell, Harold S. Pierce, and Ferdinand F. Waechter; Associate, Herbert B. Allen, Edwin Smith and George D. Van Sciver; Junior, Harry P. Hammond, Horace G. Hill, Jr., William J. Taggart, and J. Howard Van Sciver.

Mr. Earle B. Phelps, visitor, presented the paper of the evening, entitled "The Disinfection of Water and Sewage," which was discussed by Messrs. F. Herbert Snow, George S. Webster, G. E. Datesman, Henry Leffmann, M. R. Pugh, R. H. Klauder, P. A. Maignen, and Mr. Phelps. Upon motion of Mr. Easby a vote of thanks was extended to Mr. Phelps.

Following the paper of the evening, Mr. F. Herbert Snow read a paper entitled "The Unification and Federation of Engineers in Pennsylvania," the discussion of which, upon suggestion of Dr. Leffmann, was postponed to some regular Club meeting in the near future.

Upon motion, the meeting adjourned at 10.35 P. M.

THIRTY-FIRST ANNUAL MEETING, February 5, 1910.—The meeting was called to order by President Dallett with 129 members and visitors in attendance. The minutes of the Business Meeting of January 15th were approved as printed in abstract.

The Secretary announced that at the last meeting of the Board of Directors Mr. James Christie had been elected First Vice-President to fill the vacancy created by the election of Mr. Easby to the Presidency; and that Mr. H. E. Ehlers had been elected Director to fill the place vacated by Mr. Christie.

The Secretary also announced the death of Mr. Thomas C. Craig, Active Member, elected December 1, 1907; died January 26, 1910.

REGULAR MEETING, March 19, 1910.—The meeting was called to order by President Easby at 8.40 P. M., with 112 members and visitors in attendance. The minutes of the Business Meeting of March 5th were approved as printed in abstract.

Mr. Simon Lake, Visitor, presented the paper of the evening, entitled "The Principles Involved in the Design, Construction, and Operation of Submarine Vessels," which was discussed by Messrs. S. G. Comfort, Carl Hering, S. M. Swaab, C. C. Willits, Wm. Easby, Jr., Richard Gilpin, John C. Trautwine, Jr., and others.

Upon motion of Mr. Comfort, a vote of thanks was extended to Mr. Lake for his interesting and instructive paper.

Upon motion, the meeting adjourned at 11 P. M.

ADJOURNED REGULAR MEETING, January 15, 1910.—Present: President Dallett, Vice-President Wm. Easby, Jr., Directors Clarke, Twining, Christie, Develin, Plack, Mebus, Wood, the Secretary, and the Treasurer.

The following resignations were accepted as of December 31, 1909. Active: John M. Hartman, J. Harvey Borton, Wayne B. Morrell, J. W. Ridpath, Walter C. Aucott, Chas. H. Thumlert, J. V. Stanford, Elmer E. Melick, and John S. Haug.

Mr. H. P. White, Active Member, and Charles F. Chambers, Junior Member, dropped on January 4, 1910, were, upon request, reinstated in membership.

Mr. Wm. Easby, Jr., in view of his approaching election to the Presidency, tendered his resignation as Vice-President of the Club, which was accepted as of February 5th.

Upon motion, Mr. James Christie was elected Vice-President to fill the place vacated by Mr. Easby, for a term expiring February, 1911.

Mr. H. E. Ehlers was then elected a member of the Board of Directors, to fill the place vacated by Mr. Christie, term expiring February, 1911; both elections to take effect February 5, 1910.

The Treasurer presented the statement of the accountants for the month of December, and also for the year of 1909, the annual statement showing a net loss of $2230.71.

It was ordered that the President and Treasurer be authorized to reduce the existing loan of $4000 from the Colonial Trust Company, to a $2000 loan for sixty days.

It was ordered that the incidental expenses of the Trustees of the Bond Redemption Fund be charged to the general expenses of the Club.

The report of the Executive Committee was approved and given to the Secretary for final revision, the revised report to be submitted to a special Committee, consisting of Wm. Easby, Jr., J. O. Clarke, H. E. Ehlers, and Charles F. Mebus.

ORGANIZATION MEETING, February 7, 1910.—Present: President Easby, Vice-Presidents Christie and Hewitt, Directors Plack, Mebus, Hutchinson, Wood, Ehlers, Vogleson, Wilson, Halstead, and the Secretary in attendance.

The annual report of the Board of Directors, as revised by the special committee and printed, was officially approved.

It was ordered that the Art Committee, W. L. Plack, Chairman, George T. Gwilliam, and three other members to be appointed, be continued.

The President then appointed the following to serve as standing Committees for the ensuing year:

*House:* W. L. Plack, H. P. Cochrane, Percy H. Wilson, A. C. Wood, F. K. Worley.
*Meetings:* W. P. Taylor, Chas. Hewitt, A. C. Wood.
*Membership:* Chas. Hewitt, James Christie, Chas. F. Mebus.
*Finance:* James Christie, H. E. Ehlers, Henry Hess.
*Publication:* Chas. F. Mebus, R. G. Develin, J. A. Vogleson.
*Library:* H. P. Cochrane, Edw. S. Hutchinson, H. E. Ehlers.
*Publicity:* David Halstead, George T. Gwilliam, W. P. Taylor.
*Advertising:* H. E. Ehlers, E. J. Kerrick, R. G. Develin.

The following were then elected by the Board to serve as Tellers and Auditors:

*Tellers:* Edwin M. Evans, E. J. Dauner, Louis S. Bruner.
*Alternate Tellers:* Alan Corson, H. F. Sanville, L. R. Ferguson.
*Auditors:* W. B. Riegner, C. H. Ott, D. Robert Yarnall.

Upon recommendation of the Finance Committee, the following method of handling the bonds transferred to the Club by Mr. J. M. Dodge for the Link Belt Engineering Company was approved:

"These bonds shall have the detached coupons reattached, and the funds collected as interest shall be repaid to the Club by the Trustees.

"These bonds, with their full complement of coupons, shall remain in the custody of the Trustees until such time as the Board of Managers of the Club, shall require them, but the Trustees shall be relieved of further duty in connection with said bonds.

"An account to represent these bonds shall be opened in the books of the Club, credit being given for their face value.

"From time to time, as members are created upon the nomination of Mr. Dodge or other authorized officials of the Link Belt Engineering Company, the initiation fees and dues of such members shall be charged against the bonds and semi-annually thereafter the periodic dues of said members shall be charged up to the time limit specified in the agreement between Mr. Dodge and the Club.

"When the charges against the bonds shall balance their value, the bonds shall be canceled, and Mr. Dodge or his representatives notified of the fact."

The method of handling the coupons attached to these bonds was left to the discretion of the Treasurer.

The Treasurer presented the report of the accountants, which showed a net profit for the month of February of $240.76.

Upon motion, an account of $12.25 against W. S. Reid and an account of $22.00 against the Wheeling Mold and Foundry Company were ordered charged off the books.

Upon recommendation of the Committee on Meetings, a special meeting on April 30th was sanctioned.

The Committee on House presented a report of its work to date, which contained recommendations for the improvement of the Club-house.

Upon motion of the Secretary, it was ordered that a Committee be appointed to devise ways and means for raising a permanent fund for the use of the Club.

Following a report of the Committee on House on the renting of the meeting-room, it was ordered that this renting be left in the future to the discretion of the Committee on House.

Mr. Percy H. Wilson presented a detailed report of the operation of the restaurant, and, following this report, it was ordered that the Treasurer be requested to look into ways and means for improving the system of office accounts.

The resignations of Messrs. J. W. Cregar and William Warr were read and accepted as of even date.

Upon motion of Mr. Mebus, Mr. S. M. Swaab was elected a member of the Board of Directors to fill the vacancy caused by the resignation of Mr. George T. Gwilliam, term expiring February, 1912.

# PROCEEDINGS

OF

# THE ENGINEERS' CLUB

OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.




Vol. XXVII. JULY, 1910. No. 3

PAPER No. 1085.

## RATING OF PITOT TUBES.

H. C. BERRY.
(Active Member.)

*Read November 20, 1909.*

THE measurement of the quantity of water passing into the penstocks of the Ontario Power Company was a problem to which the Pitot tube was especially adapted. The writer presents to the Club this paper describing the methods employed in rating the tubes used in that work.

The intake works of the Ontario Power Company, located on the Canadian side of the Niagara River near the beginning of the rapids, consist of a large forebay protected by a curtain wall extending about 4 ft. below the surface of the water, a screen-house 600 ft. long, an inner forebay, and a gate-house at the entrance to the 18 ft. conduit. This conduit, about 6000 ft. long, is located from 3 to 30 ft. below the surface of the ground. At the lower end is a large, open, regulating chamber with an overflow discharging into the gorge.

Six 9 ft. penstocks carry the water from the large conduit to the individual turbines. Short submerged tail-races carry it from the turbines into the gorge at the back of the power-house.

this purpose a bent tube or differential gage partially filled with a suitable liquid. The latter type of gage requires two points of connection. When the tube is used in a closed pipe, one column of the gage is connected to the tube, and the other to an opening in the pipe, the "wall." A "wall" connection cannot be made in an open channel; hence, a second tube, to which the gage is connected, is inserted in the water with its opening pointed in a different direction from the first. Each is connected to a column of the gage. The two tubes inserted in the water are generally built together and are called a Pitot tube. The difference in height of the columns of liquid in the gage for any particular velocity and any particular tube is called the "head" for that tube and that velocity. Depending somewhat on the form of the "front," and more on the "back" opening, this "head" will vary for different tubes when in a stream of the same velocity, hence the necessity of rating such tubes before using them to measure the velocity of a stream of water.

The design of the tubes and special apparatus for the test of the Ontario Power Company's plant was in charge of Mr. J. C. Parker, assistant to Mr. O. B. Suhr, Construction Engineer. He was assisted by R. C. Carpenter, Professor of Experimental Engineering of Cornell University and Consulting Engineer to the Ontario Power Company. After considering the forms of tubes used by Professor Gardner S. Williams and his results as published in Vol. 47 A.S.C.E. Proceedings, they decided to use a symmetrical tube with a conical opening "front" and "back." A sample tube was made and sent to Professor Carpenter for rating. This was done in open water by mounting the tube and gage on a frame supported by two row-boats which were pushed over a course 600 ft. long by a power launch. About 60 runs were made at velocities varying from 1.5 ft. per second to 8.5 ft. per second, which gave a coefficient varying from 0.88 to 0.94 and averaging 0.915. The tube was easily clogged by débris in the water, so the later tubes were made with a very small opening and sharp points "front" and "back." They were finished by hand to bring the openings in the center of the points.

Because of the time required for rating by boat, arrangements were made to use the equipment of the College of Civil Engineering of Cornell University and rate the tubes in a closed pipe. T. J. Rodhouse, Professor of Hydraulics in the University of Missouri, then a Fellow in the College of Civil Engineering at Cornell, was engaged with the writer to rate the tubes, some fifty in number,

By "comparison in the pipe" is meant the simultaneous observation of the head on the gage of a tube to be rated and that of a standard tube, both being set at the middle of the same pipe carrying water at a velocity for which the standard tube is known to give accurate results. The comparisons should cover a wide range of velocities.

By an "open channel rating" is meant observing the "head" on the gage when the tube is inserted in a stream moving at a velocity determined by current meters.

By a "boom rating" is meant observing the "head" on the gage and the velocity with which the tube is moved in the water, when both are mounted on a boom turned at an observed rate.

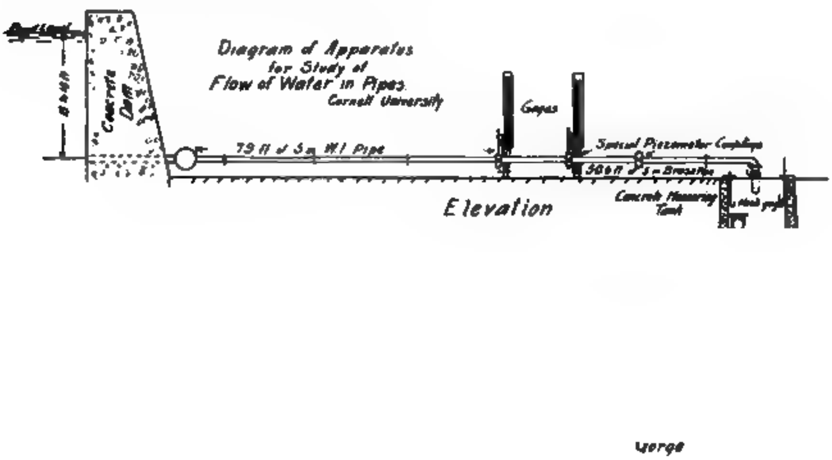



Fig. 4.

It is considered best to rate a tube under the same conditions, as nearly as they can be attained, as those in which the tube is to be used as a measuring apparatus. Since it was intended in the test of the Ontario plant to use the tubes in an open channel very near to the entrance to the conduit, it was considered that the conditions were nearly the same as in a pipe, and therefore it would be well to compare the ratings by the different methods for some of the tubes. For this comparison to be of any value it is necessary to describe the conditions under which the different ratings were made.

A diagrammatic outline of the apparatus used in the "pipe ratings" and in the "comparison in the pipe" ratings is shown in Fig. 4. It consisted of an opening through the dam connected to a small header

tially of a hollow ring connected to the pipe by an annular opening about 0.01 in. wide. There were four 1 in. openings 90 degrees apart through which tubes could be inserted. The openings had plugs fitted to give a smooth interior to the pipe. The outside thread shown was for the attachment of the stuffing boxes of the tubes.

The stem of the tube fitting in the stuffing box was provided with a short pointer or indicator which was adjusted to the lowest "position" on the scale when the tube was set against the further side of the pipe. The point of the tube was thus located for setting on the 21 "positions" shown in Fig. 7. These "positions" were at the intersection of the diameter with the edges of 10 rings of equal area into which the cross-section is divided in order to lessen the labor of working up the observations.

Differential gages with three columns were used in all the work on this pipe. The details of these are the same as were used by Prof. G. S. Williams in his work at Detroit and described in Vol. 47 of the Proceedings A. S. C. E. The units on the scales were two centimeters long. The d. c. m. in the headings of some of the tables given later refer to this double centimeter unit. The air-cocks at the lower end of the columns were of great convenience in removing air-bubbles from the connections and in adjusting the height of the water in the gages before beginning a run. The gages used at Niagara were of essentially the same design but simpler in detail. The gages of all tubes mounted on one frame were connected at the top, and consequently under a common pressure. By this plan they could all be pumped at one time.

Three of the four forms of tubes used during the ratings are shown in Fig. 6. The fourth form was made on the same lines as the tubes used in the test, but the openings were conical, being about $\frac{1}{4}$ in. in diameter at the outer ends. The Williams tube "A" had been used in the Detroit experiments. Because of its sharp lines and narrow width it produced less disturbance in the water and less reduction of the area of the pipe than the other tubes. On this account it was taken as the standard in the "comparison in pipe" ratings. Its point was $\frac{3}{32}$ in. from the end, which prevented readings being made at "position" 21, the further side of the pipe. The openings were $\frac{1}{32}$ in. in diameter, that at the front as nearly on a knife edge as possible, and the two openings at the back were on the sides and so far back as to be on the curved surface.

The tube used in the test was a bronze casting 3 in. long, machined

divide the section of the pipe into ten concentric rings of equal area and make an observation with the point of the tube set on the division lines between the rings along the diameter traversed by the tube. The settings were made by use of the pointer and scale mentioned above. The mean velocity of the water in the pipe was determined by finding the quantity of water delivered in a measured time by use of the deflector and measuring tank.

The procedure followed in making a run was, first, to test the gage by noting if the water columns were the same height when the valve was closed or when the tube was withdrawn from the pipe into the stuffing box. If they were not, it was necessary to open the cocks to permit the water to flow through the gage and to manipulate the hose so as to drive out any entrained air. With the gage adjusted, the tube was thrust to the further side of the pipe and the pointer set on the divided scale to indicate the bottom, "position 21." The tube was then set at the center of the pipe and the regulating valve opened till the desired velocity was obtained. A reading on the three columns of the gage was then made. One of these was connected to the "front," one to the "back," and one to the "wall," so that $h_t$ means the difference between the height of the column connected to the "front" and that connected to the "back," and $h_w$ the difference between the column connected to the point of the tube and that to the "wall." After this center reading was taken a five-minute run was made at the tank for the volume flowing in that time. Then readings on the gages were made at "positions" 1 to C and another run of five minutes made at the tank. "Positions" 12 to 20 were then read and the tube again set at C, a reading made, and a third run made at the tank for quantity flowing in five minutes. The top of the columns vibrated considerably, depending on the velocity, so it was customary to make three readings on each column at each "position" and take the mean as the real height in making the reductions.

The notes were worked up in the field and the coefficient found by the following computations. $H_t$ and $h_w$ were found by taking the differences between the means of the readings of height of columns to "point" and "back," and "point" and "wall" respectively for each position. Then each head was reduced to velocity by the equation

$$v = \sqrt{2gh} \text{ which becomes } V = 2.05 \sqrt{h}$$

for V in ft. per sec. and $h$ in d.c.m. This required a single setting of the slide rule for each head. Since the readings were taken at the

as that at 1 is reasonable, but the traverses show a distortion on the side remote from that at which the tube is inserted, and if a smooth curve be drawn through positions 18, 19, and 20 and continued it will reach 21 at a considerably larger value than that at 1. From this cause the computed values of $v_m$ are from 0.5 to 1.2 per cent. less than would be obtained if the symmetrical curve were used.

(*c*) A third source of error in the reduction of the data is in the assumption that the volume computed, the $v_m$ times the area of the pipe, is the same as the volume of revolution generated by the rotation of the plot of the traverse. The amount of this error is roughly shown by taking an ellipse and 21 divisions; the difference obtained by the method used and the actual value of the ellipsoid of revolution is about 0.6 of 1 per cent.

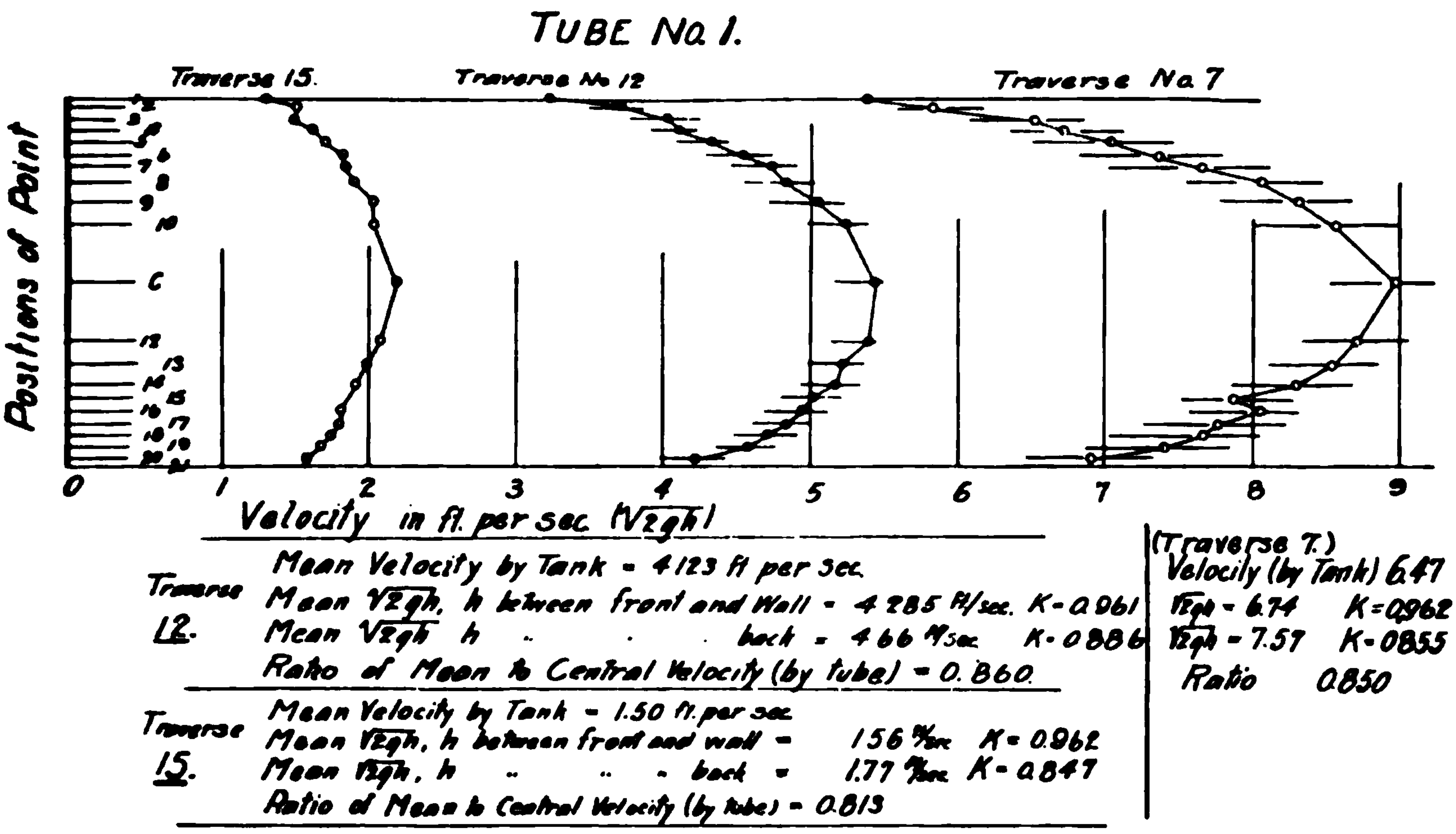



FIG. 8.

(*d*) If for any particular tube *h* does not vary exactly with the square of *v*, as is indicated in some of the results of the "boom rating," the method of reporting the rating of such tubes by means of a numerical coefficient to be applied to that relation will lead to error. In ratings made in a closed pipe a comparatively wide range of velocities is involved in running each traverse. All these are considered in computing the coefficient for that particular mean velocity, and consequently any effects due to a slight divergence from the second power of *v* being proportional to *h* would be obscured.

It was the practice of Professor Williams in the Detroit tests to modify the above formula by using the central velocity twice and dividing the sum by 21 instead of 20, as above. This was "to compensate for the deficiency occurring from the summation of the several velocities." This modification, if applied to the traverses shown, would increase the reported velocities very nearly 1 per cent.

WILLIAMS TUBE "A."

*Traverse No. 1. Rating in 5 in. Brass Pipe.*

| Position. | $H_w$ (Double Centimeters.) | $H_p$ (Double Centimeters.) | $V_w$ (Feet per Sec.) | $V_p$ (Feet per Sec.) | U (Mean Velocity by Tank.) |
|---|---|---|---|---|---|
| C | 6.50 | 10.08 | .... | .... | 4.335 ft. per sec. |
| 1 | 2.18 | 2.60 | 3.02 | 3.31 | .. |
| 2 | 2.97 | 3.73 | 3.54 | 3.97 | .. |
| 3 | 3.55 | 4.46 | 3.87 | 4.34 | .. |
| 4 | 3.96 | 5.14 | 4.09 | 4.65 | .. |
| 5 | 3.09 | 5.55 | 4.10 | 4.84 | .. |
| 6 | 4.62 | 6.20 | 4.42 | 5 11 | .. |
| 7 | 4.74 | 6.61 | 4.47 | 5.28 | .. |
| 8 | 4.73 | 6.89 | 4.47 | 5.39 | .. |
| 9 | 5.30 | 7.60 | 4.73 | 5.66 | .. |
| 10 | 5.81 | 8.30 | 4.96 | 5.92 | .. |
| C | 6.48 | 9.96 | 5.22 | 6.47 | 4.336 ft. per sec. |
| 12 | 6.10 | 9.60 | 5.07 | 6.36 | .. |
| 13 | 5.75 | 9.21 | 4.92 | 6.24 | .. |
| 14 | 5.44 | 8.91 | 4.79 | 6.13 | .. |
| 15 | 5.28 | 8.56 | 4.71 | 6.01 | .. |
| 16 | 4.88 | 7.95 | 4.54 | 5.79 | .. |
| 17 | 4.61 | 7.60 | 4.44 | 5.66 | .. |
| 18 | 4.30 | 7.13 | 4.26 | 5.48 | .. |
| 19 | 3.70 | 6.37 | 3.95 | 5.18 | .. |
| 20 | 2.98 | 4.78 | 3.54 | 4.49 | .. |
| 21 | Not observed | .... | .... | .... | .. |
| C | 6.48 | 9.76 | .... | .... | 4.336 ft. per sec. |
| | | Mean..... | 4.354 | 5.314 | 4.336 |

Coefficient, Point and Back $= \frac{U}{V_p} = \frac{4.336}{5.314} = 0.816.$

Coefficient, Point and Wall $= \frac{U}{V_w} = \frac{4.336}{4.354} = 0.997.$

Ratio of Mean Velocity by Front and Back to the Central Velocity $= \frac{5.31}{6.47} = 0.82.$

## TUBE No. 1.

*Traverse No. 7. Rating in 5 in. Pipe.*

| Position. | $H_w$ | $H_p$ | $V_w$ | $V_p$ | U |
|---|---|---|---|---|---|
| | Double Centimeters. | | Feet per Sec. | | Mean Velocity by Tank. |
| C .......... | 11.44 | 14.34 | .... | .... | .. |
| 1.......... | 4.44 | 5.39 | 4.88 | 5.37 | .. |
| 2.......... | 5.22 | 6.30 | 5.28 | 5.81 | .. |
| 3.......... | 6.74 | 8.17 | 6.02 | 6.52 | .. |
| 4.......... | 7.17 | 8.44 | 6.20 | 6.72 | .. |
| 5.......... | 7.74 | 9.27 | 6.44 | 7.03 | .. |
| 6.......... | 8.49 | 9.36 | 6.75 | 7.36 | .. |
| 7.......... | 8.93 | 10.88 | 6.93 | 7.64 | .. |
| 8.......... | 9.34 | 12.17 | 7.08 | 8.06 | .. |
| 9.......... | 9.84 | 12.85 | 7.26 | 8.30 | .. |
| 10.......... | 10.54 | 13.73 | 7.52 | 8.56 | .. |
| C .......... | 11.52 | 14.76 | 7.86 | 8.93 | .. |
| 12.......... | 10.86 | 14.08 | 7.65 | 8.70 | .. |
| 13.......... | 10.63 | 13.65 | 7 56 | 8.56 | .. |
| 14.......... | 10.09 | 12.80 | 7.35 | 8.28 | .. |
| 15.......... | 9.07 | 11.44 | 6.96 | 7.84 | .. |
| 16.......... | 9.71 | 12.08 | 7.21 | 8.06 | .. |
| 17.......... | 8.69 | 11.24 | 6.83 | 7.77 | .. |
| 18.......... | 8.29 | 10.92 | 6.68 | 7.66 | .. |
| 19.......... | 7.68 | 10.21 | 6.42 | 7.40 | .. |
| 20.......... | 6.67 | 8.82 | 5.90 | 6.88 | .. |
| 21.......... | Not observed | ..... | .... | .... | .. |
| C .......... | 11.41 | 15.07 | .... | .... | 6.47 ft. per sec. |
| | | Mean..... | 6.74 | 7.57 | .. |

Coefficient, Point and Back $= \frac{U}{V_p} = \frac{6.47}{7.57} = 0.855.$

Coefficient, Point and Wall $= \frac{U}{V_p} = \frac{6.47}{6.74} = 0.962.$

Ratio of Mean Velocity by Front and Back to the Central Velocity $= \frac{7.57}{8.93} = 0.85.$

TUBE No. 1.

*Traverse No. 15. Rating in 5 in. Brass Pipe.*

| Position. | $H_w$ | $H_p$ | $V_w$ | $V_p$ | U |
|---|---|---|---|---|---|
| | Double Centimeters. | | Feet per Sec. | | Mean Velocity by Tank. |
| C | 0.85 | 1.13 | .. | .. | .. |
| 1 | 0.21 | 0.39 | 0.94 | 1.28 | .. |
| 2 | 0.41 | 0.54 | 1.32 | 1.51 | .. |
| 3 | 0.43 | 0.53 | 1.35 | 1.49 | .. |
| 4 | 0.47 | 0.61 | 1.41 | 1.60 | .. |
| 5 | 0.50 | 0.68 | 1.45 | 1.69 | .. |
| 6 | 0.64 | 0.70 | 1.64 | 1.80 | .. |
| 7 | 0.67 | 0.80 | 1.68 | 1.83 | .. |
| 8 | 0.68 | 0.84 | 1.69 | 1.87 | .. |
| 9 | 0.70 | 0.96 | 1.72 | 2.01 | .. |
| 10 | 0.76 | 0.97 | 1.67 | 2.02 | 1.50 ft. per sec. |
| C | 0.82 | 1.13 | 1.86 | 2.18 | .. |
| 12 | 0.81 | 1.01 | 1.85 | 2.06 | .. |
| 13 | 0.72 | 0.93 | 1.74 | 1.98 | .. |
| 14 | 0.71 | 0.87 | 1.73 | 1.91 | .. |
| 15 | 0.66 | 0.79 | 1.67 | 1.82 | .. |
| 16 | 0.61 | 0.78 | 1.60 | 1.81 | .. |
| 17 | 0.64 | 0.73 | 1.64 | 1.75 | .. |
| 18 | 0.55 | 0.68 | 1.52 | 1.69 | .. |
| 19 | 0.49 | 0.66 | 1.43 | 1.67 | .. |
| 20 | 0.44 | 0.58 | 1.56 | 1.36 | .. |
| 21 | Not observed | .. | .. | .. | .. |
| | | Mean | 1.56 | 1.77 | .. |

$$\text{Coefficient, Front and Back} = \frac{U}{V_p} = \frac{1.50}{1.77} = 0.847.$$

$$\text{Coefficient, Front and Wall} = \frac{U}{V_w} = \frac{1.50}{1.56} = 0.961.$$

$$\text{Ratio of Mean Velocity by Front and Back to Central Velocity} = \frac{1.77}{2.18} = 0.813.$$

## RESULTS OF TRAVERSES.

### Williams Tube "A."

| Serial No. of Traverse. | Mean Velocity by Tank. | Coefficient. Front and Back. | Coefficient. Front and Wall. | Ratio of Mean to Central Velocity, both Observed by Front and Back. |
|---|---|---|---|---|
| 1......... | 4.336 | 0.816 | 0.997 | 0.822 |
| 2......... | 6.525 | 0.814 | 0.983 | 0.825 |
| 3......... | 9.210 | 0.810 | 0.980 | 0.827 |
| 4......... | 3.025 | 0.827 | 1.004 | 0.826 |
| 5......... | 3.527 | 0.834 | 1.023 | 0.813 |
| 6......... | 5.161 | 0.825 | 0.992 | 0.818 |
| 7......... | 6.475 | 0.825 | 1.000 | 0.825 |
| 8......... | 2.260 | 0.842 | 1.032 | 0.818 |
| 9......... | 8.980 | 0.819 | 1.004 | 0.820 |
| | Mean | 0.823 | 1.001 | 0.821 |

### Tube No. 1. (Conical Openings.)

| | | | | |
|---|---|---|---|---|
| 1......... | 5.835 | 0.837 | 0.982 | 0.849 |
| 2......... | 4.785 | 0.824 | 0.964 | 0.847 |
| 3......... | 3.025 | 0.849 | 0.973 | 0.838 |
| 4......... | 3.527 | 0.869 | 0.952 | 0.868 |
| 5......... | 5.156 | 0.865 | 0.958 | 0.862 |
| 6......... | 6.475 | 0.855 | 0.962 | 0.850 |
| 7......... | 2.247 | 0.855 | 0.960 | 0.815 |
| 8......... | 5.241 | 0.878 | 0.960 | 0.859 |
| 10......... | 7.788 | 0.892 | 0.987 | 0.862 |
| 11......... | 3.456 | 0.846 | 0.931 | 0.855 |
| 12......... | 4.123 | 0.886 | 0.961 | 0.860 |
| 13......... | 4.500 | 0.847 | 0.961 | 0.813 |
| | Mean | 0.856 | 0.963 | 0.847 |

### Tube No. 2. (Form Used on Test.)

| | | | | |
|---|---|---|---|---|
| 1......... | 6.28 | 0.889 | 1.008 | 0.840 |
| 2......... | 3.35 | 0.901 | 1.000 | 0.845 |
| 3......... | 5.23 | 0.880 | 1.000 | 0.862 |
| | Mean | 0.890 | 1.003 | 0.849 |

## Comparison in Pipe.

The method of "comparison ratings in the pipe" was adopted because of lack of time to run traverses covering a satisfactory range of velocities with each tube. It required an hour of rapid work to take the data of a traverse, and in event of trouble with air-bubbles this time was often doubled. Williams tube "A" was rated over a wide range of velocities; a sufficient number of traverses were run to determine quite accurately the value of the coefficient. It was therefore decided to place it and each of the other tubes in the center of the pipe and observe simultaneously the heads for a wide range of velocities. Since we had also determined a constant for the ratio of the velocity at the center to the mean velocity in the pipe, one point on each rating was checked by making a run at the tank for the mean velocity, to which the ratio was applied, and the central velocity found. This with the observed head gave one independent point on the rating curve. In making the comparison ratings ten readings were taken covering a range of velocities from about 1.5 to about 15 ft. per sec. The reduction of the data consisted only in finding the simultaneous heads on the two tubes and multiplying the coefficient of the Williams tube by the square root of the ratio of the head on it to that on the tube being rated.

$$K_t = K_w \sqrt{\frac{h_w}{h_t}}.$$

The results of the ratings by this method are given below for a few tubes only which were also rated by other methods in order to compare the values of $k$ found by the different methods.

## RATING BY "COMPARISON IN PIPE."

### Tube No. 2. Compared With Williams Tube "A."

| Reading No. | Simultaneous Heads. in c. m. Tube A. | No. 2. | $\sqrt{\frac{H_A}{H_2}}$ |
|---|---|---|---|
| | 20.30 | 15.80 | 1.135 |
| | 14.60 | 11.60 | 1.12 |
| | 8.65 | 6.80 | 1.128 |
| | 5.40 | 4.22 | 1.134 |
| | 2.60 | 2.47 | 1.035 |
| | 14.55 | 11.38 | 1.13 |
| (Mean velocity by tank for 6 was 5.187 ft. per sec.) | | | |
| | 19.64 | 15.83 | 1.115 |
| | 6.50 | 5.33 | 1.102 |
| | 3.10 | 2.62 | 1.087 |
| | 13.00 | 10.50 | 1.112 |
| (Mean velocity by tank for 10 was 6.11 ft. per sec.) | | | |
| | | | Mean 1.11 |

Coefficient Williams "A" = 0.825
Coefficient No. 2 = 0.825 × 1.11 = 0.915

### Tube No. 5. Compared with Williams Tube "A."

| | | | |
|---|---|---|---|
| | 1.38 | 1.28 | 1.035 |
| | 3.77 | 2.82 | 1.155 |
| | 6.98 | 4.86 | 1.195 |
| | 10.94 | 7.25 | 1.230 |
| | 18.70 | 11.93 | 1.255 |
| | 26.28 | 16.36 | 1.265 |
| | 36.37 | 23.45 | 1.246 |
| | 10.12 | 6.60 | 1.238 |
| | | | Mean 1.202 |

Coefficient No. 5 = 0.825 × 1.202 = 0.996

### Tube No. 6. Compared with Williams Tube "A."

| | | | |
|---|---|---|---|
| | 31.02 | 21.19 | 1.21 |
| | 26.40 | 17.93 | 1.21 |
| | 18.76 | 12.90 | 1.20 |
| | 11.53 | 8.25 | 1.18 |
| | 1.20 | 1.13 | 1.03 |
| | 3.89 | 3.06 | 1.13 |
| | 30.57 | 20.88 | 1.21 |
| | 10.82 | 7.84 | 1.18 |
| | | | Mean 1.17 |

Coefficient No. 6 = 0.825 × 1.17 = 0.966

TUBE No. 7. COMPARED WITH WILLIAMS TUBE "A."

| Reading No. | Simultaneous Heads. d. c. m. Tube A. | No. 7. | $\sqrt{\frac{H_A}{H_7}}$ |
|---|---|---|---|
| 1 | 37.85 | 23.40 | 1.272 |
| 2 | 32.86 | 20.49 | 1.268 |
| 3 | 26.67 | 16.77 | 1.266 |
| 4 | 18.88 | 11.86 | 1.262 |
| 5 | 11.57 | 7.50 | 1.240 |
| 6 | 1.47 | 1.15 | 1.130 |
| 7 | 6.72 | 4.49 | 1.225 |
| 8 | 4.59 | 3.53 | 1.143 |
| 9 | 1.55 | 1.20 | 1.137 |
| 10 | 0.49 | 0.45 | 1.042 |
| | | | Mean 1.216 |

Coefficient of No. 7 = 0.825 × 1.216 = 1.003

TUBE No. 8. COMPARED WITH WILLIAMS TUBE "A."

| | | | $\sqrt{\frac{H_A}{H_8}}$ |
|---|---|---|---|
| 1 | 30.09 | 23.02 | 1.16 |
| 2 | 24.29 | 17.84 | 1.16 |
| 3 | 20.54 | 15.22 | 1.16 |
| 4 | 17.05 | 12.73 | 1.16 |
| 5 | 13.39 | 10.07 | 1.15 |
| 6 | 4.57 | 4.37 | 1.02 |
| 7 | 9.37 | 7.12 | 1.14 |
| | | | Mean 1.14 |

Coefficient of No. 8 = 0.825 × 1.14 = 0.942

TUBE No. 13. COMPARED WITH WILLIAMS TUBE "A."

| | | | $\sqrt{\frac{H_A}{H_{13}}}$ |
|---|---|---|---|
| 1 | 8.37 | 6.21 | 1.16 |
| 2 | 15.21 | 11.00 | 1.18 |
| 3 | 22.63 | 16.20 | 1.18 |
| 4 | 31.00 | 22.31 | 1.18 |
| 5 | 35.08 | 25.03 | 1.18 |
| 6 | 1.71 | 1.41 | 1.10 |
| 7 | 3.98 | 3.10 | 1.135 |
| 8 | 7.65 | 5.70 | 1.16 |
| 9 | 11.55 | 8.50 | 1.165 |
| | | | Mean 1.16 |

Coefficient of No. 13 = 0.825 × 1.16 = 0.956

## RATING BY USE OF CAR OVER STILL WATER.

### Williams Tube "A."

| Run No. | Velocity, Ft. per Sec. | Head. d. c. m. | Coefficient. |
|---|---|---|---|
| 1 | 3.40 | 4.12 | 0.815 |
| 2 | 3.25 | 4.08 | 0.787 |
| 3 | 4.52 | 7.62 | 0.795 |
| 4 | 1.97 | 1.36 | 0.825 |
| 5 | 2.74 | 2.68 | 0.815 |
| 6 | 2.76 | 2.51 | 0.850 |
| 7 | 2.30 | 1.85 | 0.824 |
| 8 | 1.89 | 1.19 | 0.844 |
| 9 | 1.28 | 0.58 | 0.821 |
| 10 | 3.28 | 3.93 | 0.803 |
| 11 | 3.62 | 4.38 | 0.843 |
| 12 | 3.66 | 4.20 | 0.866 |
| 13 | 4.26 | 5.75 | 0.861 |
| 14 | 3.46 | 4.14 | 0.837 |
| 15 | 3.87 | 5.41 | 0.810 |
| 16 | 3.38 | 4.13 | 0.810 |
| 17 | 3.78 | 5.19 | 0.810 |
| 18 | 2.86 | 2.80 | 0.833 |
| | | Mean | 0.825 |

### Tube No. 1. (Conical Point and Back.)

| | | Head in Inches. | |
|---|---|---|---|
| 1 | 3.73 | 3.54 | 0.862 |
| 2 | 3.46 | 2.80 | 0.891 |
| 3 | 4.18 | 4.35 | 0.865 |
| 4 | 4.10 | 4.50 | 0.836 |
| 5 | 2.58 | 1.58 | 0.887 |
| | | Mean | 0.872 |

### Tube No. 2.

| | | | |
|---|---|---|---|
| 1 | 2.80 | 1.53 | 0.978 |
| 2 | 2.40 | 1.11 | 0.985 |
| 3 | 1.87 | 0.76 | 0.925 |
| 4 | 1.33 | 0.39 | 0.908 |
| 5 | 3.22 | 2.15 | 0.946 |
| 6 | 3.54 | 2.42 | 0.980 |
| 7 | 3.59 | 2.67 | 0.970 |
| 8 | 3.66 | 2.72 | 0.958 |
| | | Mean | 0.956 |

### Tube No. 10.

| | | | |
|---|---|---|---|
| 1 | 3.67 | 2.51 | 1.000 |
| 2 | 4.38 | 3.46 | 1.013 |
| 3 | 2.60 | 2.67 | 0.975 |
| 4 | 3.14 | 3.21 | 0.976 |
| 5 | 3.77 | 2.70 | 0.990 |
| | | Mean | 0.991 |

An examination of this equation in connection with any plotted point on one of the rating curves will make clear the following graphic method of determining the coefficient resulting from the particular observation which the point represents.

"Draw a line through the point with a slope of 2 on 1 to intersect the horizontal; measure with the dividers the distance from point of intersection to 2.32 on the axis; if the intersection is to the right of the point 2.32, apply this length at the left end of the log. unit; if to the left, apply it to the right end of the log. unit." Note that we have used the fact that the log of a quantity less than unity is negative.

BOOM RATING IN DUFFERIN CHANNEL.

WILLIAMS TUBE "A."

| VELOCITY IN FEET PER SECOND | HEAD IN INCHES. |
|---|---|
| 4.51 | 5.99 |
| 5.16 | 7.72 |
| 3.72 | 3.77 |
| 3.94 | 4.65 |
| 2.45 | 1.81 |
| 3.44 | 3.60 |
| 5.60 | 9.94 |
| 4.24 | 5.09 |
| 1.13 | 0.63 |
| 1.53 | 0.75 |
| 1.00 | 0.46 |
| 2.47 | 1.78 |
| 2.80 | 2.44 |
| 3.03 | 2.85 |
| 3.60 | 3.86 |
| 3.10 | 2.68 |
| 3.90 | 4.45 |
| 4.48 | 5.89 |
| 2.62 | 1.97 |
| 3.62 | 4.16 |
| 5.03 | 7.64 |
| 6.95 | 14.61 |

TUBE NO. 1.

| | |
|---|---|
| 2.26 | 1.08 |
| 3.78 | 3.03 |
| 4.87 | 5.08 |
| 5.76 | 6.73 |
| 6.92 | 9.95 |
| 7.18 | 10.75 |
| 7.94 | 13.45 |
| 6.41 | 8.51 |
| 3.58 | 2.62 |
| 8.82 | 16.23 |

## STILL WATER RATING IN DUFFERIN CHANNEL.

### Tube No. 3.

| Velocity in Feet per Second. | Head in Inches. |
|---|---|
| 1.38 | 0.34 |
| 1.88 | 0.66 |
| 2.49 | 1.14 |
| 1.49 | 0.46 |
| 1.18 | 0.26 |

Above with oil in gage. Reduced to water.

| | |
|---|---|
| 3.15 | 1.80 |
| 2.61 | 1.25 |
| 4.47 | 3.67 |
| 5.71 | 5.73 |
| 6.86 | 8.10 |
| 7.58 | 10.30 |
| 9.46 | 15.62 |

### Tube No. 4.

| | |
|---|---|
| 2.66 | 1.27 |
| 4.64 | 3.83 |
| 6.28 | 6.83 |
| 7.70 | 9.78 |
| 7.88 | 10.37 |
| 3.51 | 2.16 |

### Tube No. 5.

On Boom at Dufferin Channel.

| Velocity in Feet per Second. | Head in Inches. |
|---|---|
| 2.72 | 1.51 |
| 2.19 | 0.92 |
| 2.57 | 0.97 |
| 2.05 | 0.64 |
| 1.34 | 0.41 |
| 1.55 | 0.55 |
| 1.77 | 0.55 |
| 2.46 | 0.98 |
| 2.27 | 1.02 |
| 4.10 | 2.88 |
| 5.00 | 4.12 |
| 6.05 | 5.68 |
| 6.35 | 6.84 |
| 1.82 | 0.47 |
| 2.55 | 1.20 |
| 3.49 | 2.20 |
| 3.12 | 1.64 |
| 2.19 | 0.88 |

## BOOM RATING AT CORNELL LABORATORY.

### Tube No. 7.

| Velocity in Feet per Second. | Head in Inches. |
|---|---|
| 12.2 | 26.2 |
| 11.5 | 24.0 |
| 10.8 | 21.3 |
| 10.2 | 18.4 |
| 9.6 | 17.2 |
| 8.9 | 13.5 |
| 8.0 | 12.2 |
| 7.3 | 9.6 |
| 6.1 | 6.9 |
| 5.7 | 5.9 |
| 5.1 | 5.2 |
| 4.5 | 3.8 |
| 3.9 | 2.64 |
| 3.7 | 2.52 |
| 2.45 | 1.37 |
| 2.45 | 1.21 |
| 2.00 | 0.96 |

## BOOM RATING IN DUFFERIN CHANNEL.

### Tube No. 7.

| | |
|---|---|
| 2.89 | 1.55 |
| 4.15 | 3.20 |
| 5.40 | 5.65 |
| 6.57 | 8.03 |
| 7.66 | 10.86 |
| 9.38 | 16.49 |
| 2.17 | 0.90 |

### Tube No. 8.

| Velocity in Feet per Second. | Head in Inches. |
|---|---|
| 3.22 | 2.13 |
| 3.98 | 3.19 |
| 4.34 | 3.80 |
| 5.53 | 5.47 |

### Tube No. 13.

| | |
|---|---|
| 3.44 | 2.24 |
| 4.86 | 4.10 |
| 6.12 | 6.39 |
| 6.57 | 7.30 |
| 7.30 | 9.13 |
| 8.35 | 11.70 |
| 3.11 | 1.63 |
| 2.53 | 1.19 |
| 2.35 | 1.10 |
| 3.25 | 2.04 |
| 8.66 | 12.33 |
| 8.90 | 13.55 |
| 9.40 | 14.60 |
| 8.54 | 12.07 |
| 3.02 | 1.62 |
| 4.69 | 3.85 |
| 6.26 | 6.80 |

In Figs. 9 to 17 the values of *h* and *v* observed in the boom ratings are plotted on logarithmic cross-section paper. Most of the points lie reasonably close to the heavy line drawn to represent their mean position, and thus to express the relation between V and h with which the observations agreed. The dotted line shows the $\sqrt{2gh}$ multiplied by the coefficient obtained by taking the average of the coefficients for the different observations. This line is quite different for several of the tubes, and even for tube No. 7, which was rated by this method at two different places about a year apart, there is quite a divergence between the lines, though the work of the two observers checks very closely. This would indicate that taken over a wide range of velocity the coefficient of a tube may vary; in other words, the velocity may not vary exactly as the square root of the head observed on the gage. This difference is shown for several tubes in following table:

| Tube. | Average Coef. in $V=k\sqrt{2gh}$. | Equation to Solid Line on Log. Paper. | Difference in Values of Velocity. At about 10 ft. per sec. | At 2 ft. per sec. |
|---|---|---|---|---|
| Williams A....... | 0.786 | $V=0.784\sqrt{2g}\,h^{0.50}$ | Very small differences. | |
| Rodhouse No. 1... | 0.773 | $V=0.755\sqrt{2g}\,h^{0.51}$ | 0.16=1.5% | 0.05=2½% |
| No. 1 con......... | 0.942 | $V=.976\sqrt{2g}\,h^{0.489}$ | 0.1 =1.5 | .06=3% |
| No. 3............ | 1.02 | $V=1.00\sqrt{2g}\,h^{.512}$ | 0.2 =3% | .02=1% |
| No. 4............ | 1.04 | $V=1.00\sqrt{2g}\,h^{.522}$ | —0.15=2% | +.08=4% |
| No. 5............ | 1.03 | $V=.981\sqrt{2g}\,h^{.534}$ | —0.5 =7% | +.04=2% |
| No. 7............ | 1.001 | $V=0.955\sqrt{2g}\,h^{.520}$ | 0 =0 | +.10=5% |
| No. 8............ | 0.969 | $V=0.918\sqrt{2g}\,h^{.536}$ | —3 =4% | +.10=5% |
| No. 13........... | 1.04 | $V=0.98\sqrt{2g}\,h^{.525}$ | —3 =4% | +.08=4% |

## COMPARISON OF COEFFICIENTS AS OBTAINED BY THE DIFFERENT METHODS FOR THE SEVERAL TUBES FOR WHICH RATINGS ARE SHOWN.

### Williams Tube "A."

| Method of Rating. | Range of Velocity. Ft. per Sec. | No. of Ratings. | Value of Coefficient. Mean. | Highest. | Lowest. | Per Cent. Variation from Value by Boom. |
|---|---|---|---|---|---|---|
| Traverse..... | 2.26— 8.98 | 9 | 0.823 | 0.842 | 0.810 | +4.7 |
| On Boom.... | 0.63—14.6 | 20 | 0.786 | 0.825 | 0.765 | ...... |
| On Car...... | 1.28— 4.52 | 13 | 0.825 | 0.861 | 0.787 | +5. |
| Open Ch'l... | 1.86— 1.89 | 3 | 0.831 | 0.843 | 0.820 | +5.7 |

It is evident that for some of the tubes the use of an average coefficient applied to $\sqrt{2gh}$ may give a value of V differing by from

FIG. 18.

2 to 7 per cent. from the real value as obtained by use of the true curve.

Something of this difference is shown in the variation of the value

were made in streams moving at low velocities, and the apparatus under those conditions did not give very satisfactory results. So far as can be ascertained very little use was made of this instrument until about 1850. Its satisfactory use for low velocities has been made possible by employing in connection with it a differential tube containing some liquid lighter than water for magnifying the tube deflection, thereby making the error in reading relatively smaller. For high velocities a water column may be directly read, and for very high velocities, as, for instance, in the experiments of Freeman in 1888, for determining the flow through nozzles, a liquid heavier than water is desirable.

A difference of opinion exists to-day regarding the accuracy of the Pitot tube, and the reason for this can be explained by the variation in the coefficients which have been obtained under the same experimenters, working presumably with equal care throughout their investigations.

Among the most careful series of readings are those which have been made in comparatively small cross-sections where the introduction of the tube itself has been without doubt a disturbing element. The same tubes introduced into much larger pipes would produce very much less disturbance, and it is reasonable to assume that if the calibration had been made in these pipes, the coefficients would have been different. The great value of the Pitot tube lies in its portability and its cheapness. It may be used where it would be expensive or impossible to construct weirs, or to install orifices. It is the only instrument which can be used in turbines and centrifugal pumps to obtain the velocities in the different parts.

I do not wish to give the impression that I underrate the value of the Pitot tube for obtaining discharges under the conditions mentioned. A large amount of experimental work has been done with the Pitot tube in an attempt to perfect it and the methods of its use, and there is little doubt that in the course of time the concordance of results will lead to greater confidence in its use.

John C. Trautwine, Jr.—I am especially glad to see Mr. White here this evening, inasmuch as, by a curious coincidence, I received this morning a letter from a correspondent in New Zealand, commenting upon the effect, upon the coefficient, of the suction opposite the lateral opening in a double Pitot tube.

Some ten years ago Mr. White published, in the Journal of the Association of Engineering Societies, a most illuminating paper entitled "The Pitot Tube; Its Formula," and I was sure that he could throw light upon this question of the disturbing effect which the lateral orifice has upon the coefficient.

As I understand Professors Berry and Easby, all such disturbing effects are taken care of in the coefficient, which, in their practice, is determined by rating the tube for each particular case; but, in view of the difficulty of such rating, in many cases, I think we must agree with Mr. White that it is desirable to select such an arrangement of orifices as will bring the coefficient very close to unity, thus eliminating these disturbing factors.

It may be of interest to mention that Professor Robinson has used the Pitot tube for measuring flow of air and gases, and that M. Bazin has used it for measuring the velocity in the thin sheet of water flowing over a weir, an application for which the Pitot tube is perhaps the only device that could be used.

William White.—About ten years ago I had occasion to test a centrifugal pump and to measure the flow of water in the 5-foot diameter discharge pipe of

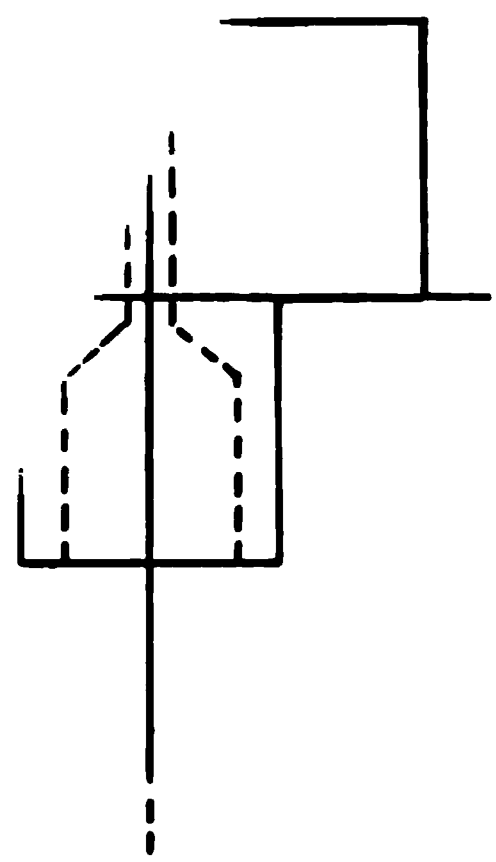


FIG. 4.

h, $\frac{1}{32}$ inch, $\frac{1}{100}$ inch, or 3 inches, or
shapes as shown by Figs. 1, 2, 3, and 4.
centrifugal pump the question came to
correct, it would be possible to get the
Referring to the figure, you will note that
an orifice in the bottom of the box. A
h the point facing the direction of flow. To
a rubber hose which passes over the top of the
orrect, the water would be capable of rising to
ne, by an amount equal to twice the head which

bows of the two boats and a Pitot tube was attached to the boom at a distance of about 2 feet in front, so that the tube would not be affected by disturbances at the bows. A glass tube was connected to the Pitot tube, and in it we could read the height to which the water would rise in the tube.

Directly above the Pitot tube and attached to the boom was a sharp knife, which extended down below the water surface. A scale was marked upon the knife and it was so related to the scale on the gage board to which the Pitot tube was connected that the reading on the knife scale at the surface of the water gave the zero of the Pitot scale. It was then an easy matter to calculate the difference between the surface of the water and the level of the water on the Pitot tube scale. Therefore, by reading the velocity head, we could calculate the velocity from the formula $V = \sqrt{2gh}$, and this velocity checked the velocity of the boat as near as could be measured.

The tests ran over a period of three or four months, for all conditions of velocity, depth, and shapes. As long as we would stick to the first principles of the Pitot tube, we found that when the point of the tube was struck with a certain velocity, the results would adhere strictly to the formula $V = \sqrt{2gh}$.

The great trouble which engineers have had in the use of the Pitot tube has resulted from the introduction of the piezometer end of the tube. I noticed to-night in Mr. Berry's paper where one of his constants between the point of the tube and a piezometer attached to the wall of the pipe was 0.997. In all cases where the Pitot tube has been used in pipes varying in diameter from 4 inches to 12 feet we have always found, as nearly as could be determined, that the coefficient of the Pitot tube is unity when referred to the pressure within the walls of the pipe.

In a recent test on the 10,000 horse-power turbines which were designed and built by the I. P. Morris Company, of Philadelphia, for Station No. 3 of the Niagara Falls Hydraulic Power and Manufacturing Company, about $3000 was spent in calibrating the Pitot tubes by two Francis weirs.

We had two weirs, each 18 feet long, with a head of 2 feet on the crests. The water was collected in a basin and discharged through two 5-foot diameter pipes. In each pipe we took two traverses with two Pitot tubes, one traverse being at right angles to the other and in the same plane, with the necessary piezometer points at the wall of the pipe. The coefficient of these tubes ranged from .97 to 1.00.

If we place the point of a Pitot tube at right angles to the direction of flow, we would then naturally assume that the reading of the tube would be the pressure head corresponding to the pressure in the pipe. Such, however, is not the case. For this particular position of the tube there is a suction action at the point of the tube, which draws the level of the water below the level corresponding to the pressure head, and the amount of this suction, of course, varies with the velocity and with the angle the tube makes with the direction of flow.

If we reverse the position of the tube so that it faces down-stream, you would expect that the suction action would be the greatest for this position. Such, however, is not the case; the suction effect here is less than that for the 90-degree position.

Let us consider a curve of this suction effect for various angles obtained by revolving the tube 360 degrees. (See Fig. 6.) Let us draw a circle and call it the

**zero line. If the tube be placed so that it faces up-stream, and assume th velocity of the water is 8 feet per second, we will get a positive reading of one foot.**

**Let us lay eight feet off on this scale outside our zero line and where the**

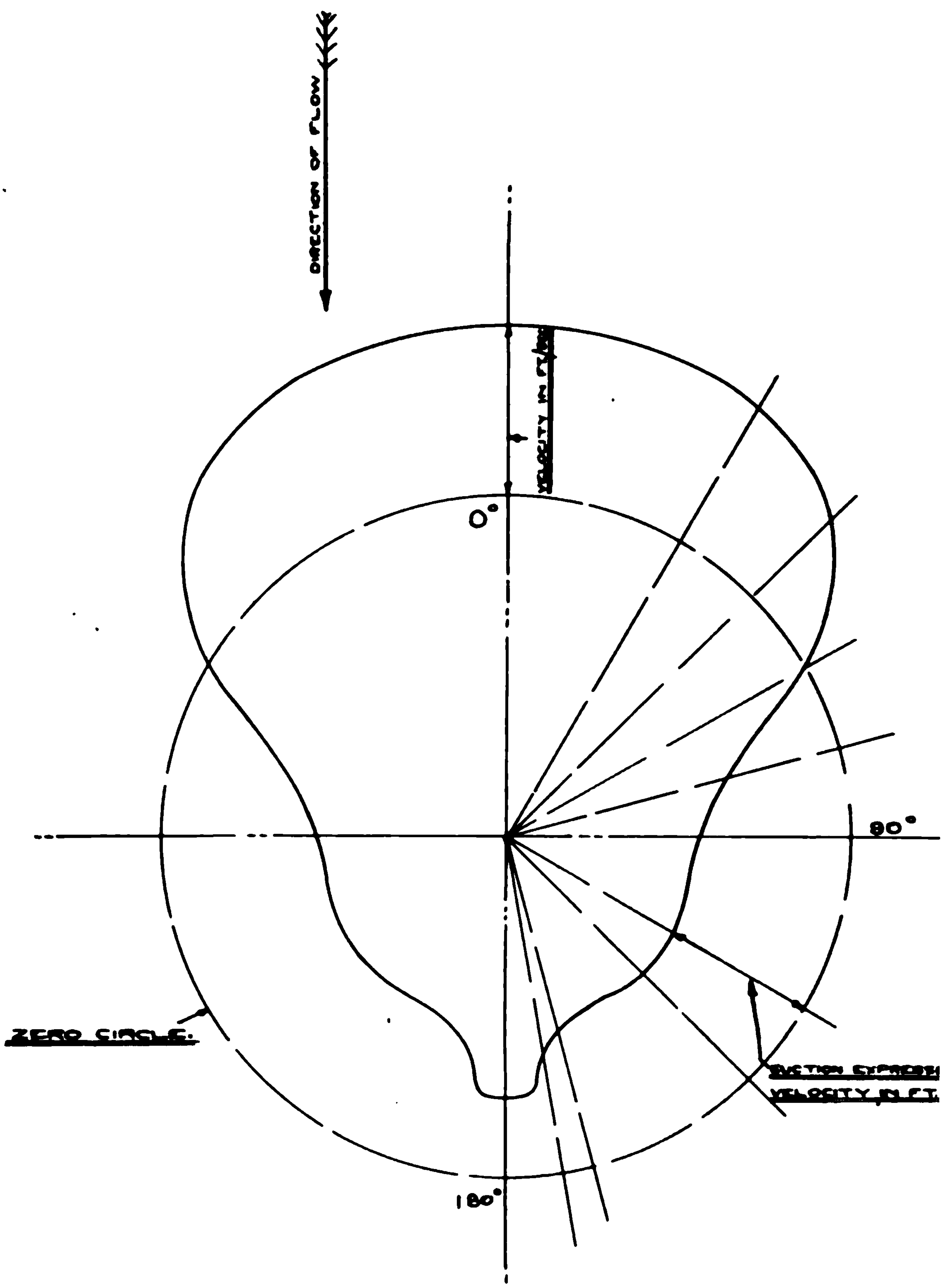



FIG. 6.

is zero degrees. Then turn the tube through 90 degrees and we get a suctior which gives a negative reading. This negative reading expressed in velo feet per second is plotted in toward the center of the zero circle at the 90-position.

us do the same thing for the 180-degree position, and we find that this will not fall very far within the zero circle. In the same manner plot the for various angles and draw a curve through them. We find that the curve -shaped.

us consider for a moment the reason for such varied results from the Pitot Consider a Pitot tube arranged as follows. (See Fig. 7.) The piezometer ing a tube made up of ½ inch pipe, ½ inch tee, and ½ inch plug with hole through the side of the tee. If the point and pressure tubes are connected ommon gage, the difference in readings will be greater than the velocity

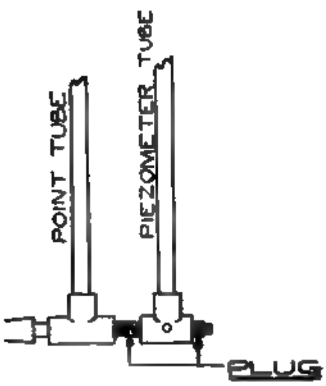



FIG. 7.

$\frac{2}{g}$ and may be expressed as $h = \left(\frac{V^2}{2g}\right) K$, where K is greater than unity. the formula as ordinarily used becomes $V = \sqrt{\left(\frac{1}{K}\right) 2gh}$, where the constant which is less than unity. This constant, however, only ap- o the pressure part of the tube, and depends on the particular shape of this Thus, in the tubes discussed to-night the constant varied from about .79 to is constant depending on the suction action The tube which had a constant t to unity was the one having the pressure opening at the back. This with the curve shown by Fig. 6, which shows minimum suction at the back. s a pity that the elements of the tube are not clearly explained in the usual

When this tube was placed in the stream either 5 inches or 5 feet down from the box, the water within the glass would always rise to the height of the pressure openings of the tube.

I then constructed a tube similar to that shown by Fig. 10, which combined the point of the tube with the new piezometer attachment. The instrument was then tested by hauling it back and forth through the canal, and the coefficient of that tube was practically unity; I do not remember it exactly now, but it was certainly not off one per cent. The tube was tested for velocities as large as 10 feet per second.

In reply to Professor Easby's question regarding suction action at a piezometer connected to the wall of the pipe, would say that this would occur only in cases where the wall of the pipe at the point where the piezometer is attached is inclined away from the direction of flow. When the wall is inclined toward the flow the piezometer will read a portion of the velocity head and the pressure in the piezometer will be increased accordingly.

On a test recently made in California we had eight piezometers around a 5-foot diameter pipe, all of these leading up to a gage board. We had two Pitot tubes at right angles to each other, and velocities of 15 to 20 feet per second in the pipe.

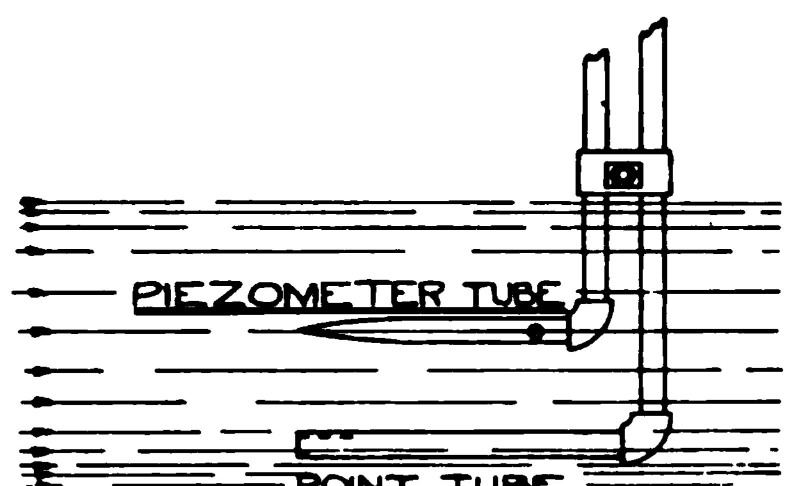



FIG. 10.

The piezometer readings would vary from ½ inch to 1 inch when the difference between them and the tubes themselves was 6 feet. Of course, as the velocity was lessened, this difference in the piezometer readings was reduced to nearly zero.

Mr. Berry.—What is the advantage, Mr. White, of having a coefficient of unity?

Mr. White.—By using a tube having unity for a coefficient, we know that we are right and can rely on the results obtained, no matter what the conditions of velocity or pressure may be. On the other hand, by using a tube having a coefficient of less than unity, an advantage might be claimed due to the larger reading obtained on the gage; but the coefficient is very uncertain, and varies not only for different tubes, but for the same tube under various conditions of flow. Owing to this fact the results are very unreliable. Therefore, if I were going to make a test I would insist on a tube with a coefficient of unity.

Prof. Easby.—Do you calibrate your Pitot tubes?

Mr. White.—No; because I have not used the tube with the coefficient. My practice is to use the Pitot tube and the piezometers at the wall of the pipe and assume the coefficient to be unity, correcting for this whirl that I mentioned due to the water not flowing in straight lines. If the whirling water has a forward

tube was used in a closed pipe. It did not do so, however, and the "piezometer tube" was used very little after a few runs were made in rating it.

It seems that it would be practical to make use of the Pitot tube instead of the standard current meters for the measurement of shallow streams, ditches, and canals. The apparatus is just as sensitive, quicker in its indications, is more easily transported, is less liable to damage in carrying, should retain its calibration better, and should be much cheaper if made by a first-class instrument-maker in reasonably large numbers.

includes railroad sleepers, mine props, construction timbers which are exposed to the weather, fence-posts, telegraph poles, grape stakes, etc. The experimental preservation of wood was first attempted in England more than a hundred years ago, and it is said that one hundred and sixty-seven different processes, involving the use of a wide range of preservative materials, were tried prior to 1874. The most rapid and practical advancement in timber preservation followed the development of the railroads, and for the last fifty years the treatment of railroad sleepers has been a widely adopted policy. The preservatives or processes used have ranged from the attempted distribution of copper sulphate into the wood of standing trees by introducing the chemical into the sapwood, to the present almost universal use of creosote forced into manufactured material by pressure processes.

The Germans probably have more to teach us than any one else, for they have experimented with a greater number of preservatives and processes and are still working more or less along experimental lines. The French railroads, on the other hand, have perhaps achieved the most substantial results, since they have long been advocates of straight creosote and have injected into the wood all that it would hold. The English railroads have also been consistent users of creosote, and although they have experimented with other preservatives, the general practice has changed but little in recent years. Out of a total of 70 treating plants in the western countries of Continental Europe, 47 are in Germany, 14 in France, and 9 in Belgium. Of this total, 14, or 20per cent., are railroad plants, the remaining 56 being under private control, although much of their work is done for the railroads and for the government telegraph and postal services. By countries, the 9 plants in Belgium are all private, while 6 out of the 47 in Germany and 8 out of the 14 in France, or 12 per cent. and 58 per cent., respectively, are owned by the railroads.

It is known that Europeans have been achieving definite results in timber treatment for half a century, and it is therefore rather disappointing to find the mechanical equipment at their treating plants far inferior to the newer and better equipped plants in this country. Owing to the cheapness of labor, they have not learned to use mechanical devices to facilitate the handling of material in and out of the cylinder and in the yard, and practically everything is still done by hand in a way which in this country would appear slow and laborious. Their cylinders, as a rule, are small, and the doors heavy and cum-

and Manheim-on-the-Rhine. This company originated the so-called Rutgers process, which is a treatment with a mixture of zinc-chlorid and creosote, and for several years treated sleepers and other timbers by this method and also with zinc chlorid alone. It was found, however, that the zinc chlorid, either in mixture with creosote or separately, leached out rapidly, failed to give adequate protection from decay, and from the railroad standpoint was unsatisfactory, because it caused the corrosion of spikes, plates, and rails in contact with it. Since their own process proved unsatisfactory, the Rutgerswerke have acquired the right to use the Reuping patent, and are rebuilding several of their plants so as to treat by this process. The Prussian State Railway, in turn, has accepted the Reuping treatment, and practically all of their work is being done by the Rutgerswerke. Although the Reuping patent has been in force only six or seven years, the Prussian Railway engineers seem to have concluded that this treatment gives as deep a penetration as is possible by any method, is permanent, does not corrode metal which comes into contact with the treated wood, and that the saving in oil—and therefore in cost—justifies the change on grounds of economy as well as efficiency. Beech ties which were treated with 36 to 40 kilos of creosote by the full-cell process are now to be given a treatment of 16 kilos, while pine ties will be impregnated with 7 kilos, although 18 and 9 kilos, respectively, were recommended by the Rutgerswerke.

The Reuping process was introduced into this country about five years ago, and the Santa Fé Railroad uses it exclusively at its large plant at Somerville, Texas. This process consists of an initial air-pressure of 40 to 80 pounds, depending on the species under treatment, followed by the introduction of the oil under an increased pressure, so that at no time is the initial pressure lost. The higher oil-pressure is held for a period varying from one to three hours, after which the oil is drawn out or forced back and a vacuum of 20 to 25 inches formed for thirty minutes to an hour. The time periods and the pressure are varied quite materially in accordance with the characteristics of the wood under treatment; well-seasoned pine, for instance, requiring only two and one-half hours; oak, about four and one-half to five hours; and beech, which in Germany is given a double Reuping treatment, seven to eight hours.

Another treatment which has been used to considerable extent in Germany, and of which little has been heard here, is the so-called creo-air process. This process eliminates the initial air-pressure, and the

person, or more than seven times as great. Railroads in this country alone use over 100,000,000 cross-ties per annum, and for their timber requirements take about 20 per cent. of all of the timber cut each year, which strips the forests from no less than a million acres. If preservative treatment did no more than double the life of timber, it would cut this consumption in half and reduce the annual drain by half a million acres per year. Such action, if coupled with measures which would keep our forest lands continually productive, would soon solve all the problems of forest conservation.

In conclusion, the author desires to outline very briefly the general situation as regards the creosote which Europe produces and furnishes for consumption all over the world. The two main sources of supply are Germany and England, practically all of the other European countries deriving most of their supply from these producing countries, but mainly from Germany.

Creosote is a by-product of a by-product, it being one of the many distillates of tar, and the tar in turn being a by-product of coke ovens or illuminating gas plants, the larger percentage of that distilled being coke-oven tar. The tar from both of these sources is assembled at distillation plants, where it is refined into four main products: light oils, solid anthracene and napthalene, creosote, and pitch. The pitch, which is used for making briquettes, usually constitutes about 50 per cent. of the total, creosote, 15 per cent., and the volatile oils and solids the remainder. The light oils, such as ammonia, benzol, etc., are usually placed on the market direct, while the solids are disposed of to other chemical plants, where they are worked up into coal-tar flavoring extracts and anilin dyes.

The German distillation plants which produce most of the creosote for the American export trade are in the coal and iron districts of Westphalia. The oil produced at the various works is shipped by barge to Amsterdam, Holland, or to Emden, Germany, where it is assembled in large shore tanks and thence pumped into tank steamers for export. The creosote produced in the plants of eastern Germany, Posen, and Silesia is disposed of locally or shipped to France and Italy. A German syndicate of tar producers and distillers practically controls the whole creosote industry on the Continent, and while the individual concerns making up the syndicate sell part of their output locally as they find a market, the greater part of the creosote produced is disposed of by a selling syndicate which represents the combination of producers and distillers. This selling syndicate entirely controls the

from that abroad. Consequently, I will not attempt to more than emphasize one or two statements concerning the general subject of wood preservation.

In regard to the corrosive action of creosote: the creosote we are using—which, by the way, is a German oil—will not only not corrode, but will prevent rust. A piece of iron or steel, filed to brightness, then dipped in creosote, if exposed to the weather, will not show any rust so long as the oil remains on the iron. If the creosote is rubbed off after standing for some time, it will be found that the metal is still bright.

Another part of the paper read called attention to the necessity of mechanical protection for the treated timber. There is no doubt that a preservative treatment with creosote will make wood decay-proof for twenty or twenty-five years; but there is no object to be gained by rendering a stick proof from decay for over twenty years, and then either crushing or spiking it to pieces in five or six. This is a feature to be noted in preservative treatment of wood, especially of railroad cross-ties.

To take up a discussion of methods of treatment would require a great amount of detail. The speaker, however, referred to a process by which the oil is forced into the wood by an air-pressure applied after the oil has been injected into the wood. From our experience, we have found that an air-pressure following an oil-pressure is of little value, especially when the air pressure is but 100 pounds following an oil pressure of 180 pounds. The oil has been found to distribute itself, leaving the air-pressure almost valueless.

The double Reuping process was also mentioned. In this connection, we have found that this double pressure will give a more satisfactory penetration than a simple pressure. For example, last week, in treating a charge of very refractory timber, by dropping the pressure from 200 pounds to 50 pounds and then bringing it up again, we found that oil could be forced into the wood about twice as fast as by maintaining a constant pressure of 200 pounds.

I believe that the Club will get a more satisfactory idea of the situation by asking questions than from any discussion, so I will not speak further.

P. A. Maignen.—I have made some laboratory experiments in wood preservation. They were suggested to me by certain passages in the "Primer of Wood Preservation," Forest Service, Circular 139:

> "The decay of a plant body," says the Primer, "such as wood, is not an inorganic process like the rusting of iron or the crumbling of stone, but is due to the activities of low forms of plant life called bacteria and fungi. . . .
>
> "The chief material of the cell walls is a substance called cellulose, and around these there are incrusted many different organic substances known collectively as lignin. Most of the wood-destroying fungi attack only the lignin; others attack the cellulose alone, while the third class destroy all parts of the wood structure. . .
>
> "But food (lignin) is not the only thing that a fungus requires for its growth and development, it must also have heat, air, and moisture. If any one of these is lacking, the fungus cannot develop. . . . Of the four requirements, two (heat and air) are beyond control. It is only by depriving the fungi of food or moisture that the destruction they cause can be prevented."

The removal of the moisture is easily done by seasoning, and this has been so well studied that little need be said about it. But the removal of the organic matter does not seem to have received much consideration. This food for the fungi —the lignin or organic matter—is also known as sap. In green wood it is associated with water. One may remove a part of the water from the wood as one

PAPER NO. 1087.

# THE FRUHLING SUCTION DREDGE.

JOHN REID.
(Visitor.)

*Read May 7, 1910.*

THE man who first set out to develop the use of the primitive form of the centrifugal suction pump soon found out that it was adapted for handling many things besides water. The absence of valves with their attendant troubles and frequent disarrangements would easily determine in favor of the use of the centrifugal pump for conditions in which the liquid to be pumped might be expected to contain a large percentage of solid matter. Sand, mud, and other materials much less homogeneous and capable of being pumped would often appear in the pump discharge, and from such handling of solids by accident to the handling of them by design, as in a suction dredge, is a simple and natural process of evolution.

The exact moment, however, in which it was first discovered that a new excavating agent of tremendous power had been developed cannot now be fixed with any certainty, nor can any one man apparently claim the merit for the discovery. From the most authentic information at the author's disposal, it would seem that the first serious practical use of the centrifugal suction dredge occurred in the later stages of the construction of the Suez Canal, that is, in the late sixties of last century. In passing, it is worthy of notice that the Suez Canal, which was begun under a terrible labor régime of practical slavery, ended by developing the most remarkable excavating appliances of that day, and among them the centrifugal pump suction dredge, which is at this date certainly the most powerful excavating appliance in the hands of the engineer.

But the progress of the development of the suction dredge was so slow that as late as 1879 a recognized authority on dredging writes as follows:

"Another of the recently suggested improvements is that by Mr. C. Randolph, who in 1870 proposed that instead of the ordinary dredging buckets, pipes should be lowered until they came into con-

different suction dredges, such as pipe-line discharging dredges or cutter-head suction dredges—all very useful tools, no doubt, in their own work and place.

The low efficiency of the ordinary suction dredge arises from two main reasons: (1) Failure to get the dredged material into the suction, and (2) failure to get it out of the discharge. The upper diagram in Fig. 1 illustrates roughly the principal features of what may be called the open-mouth suction hopper dredge, and the "Leviathan" itself, to which I have referred, is simply one of the largest and most up-to-date of this type. In this form of suction dredge there is the floating ship-shaped hull, the steam-driven centrifugal pump or

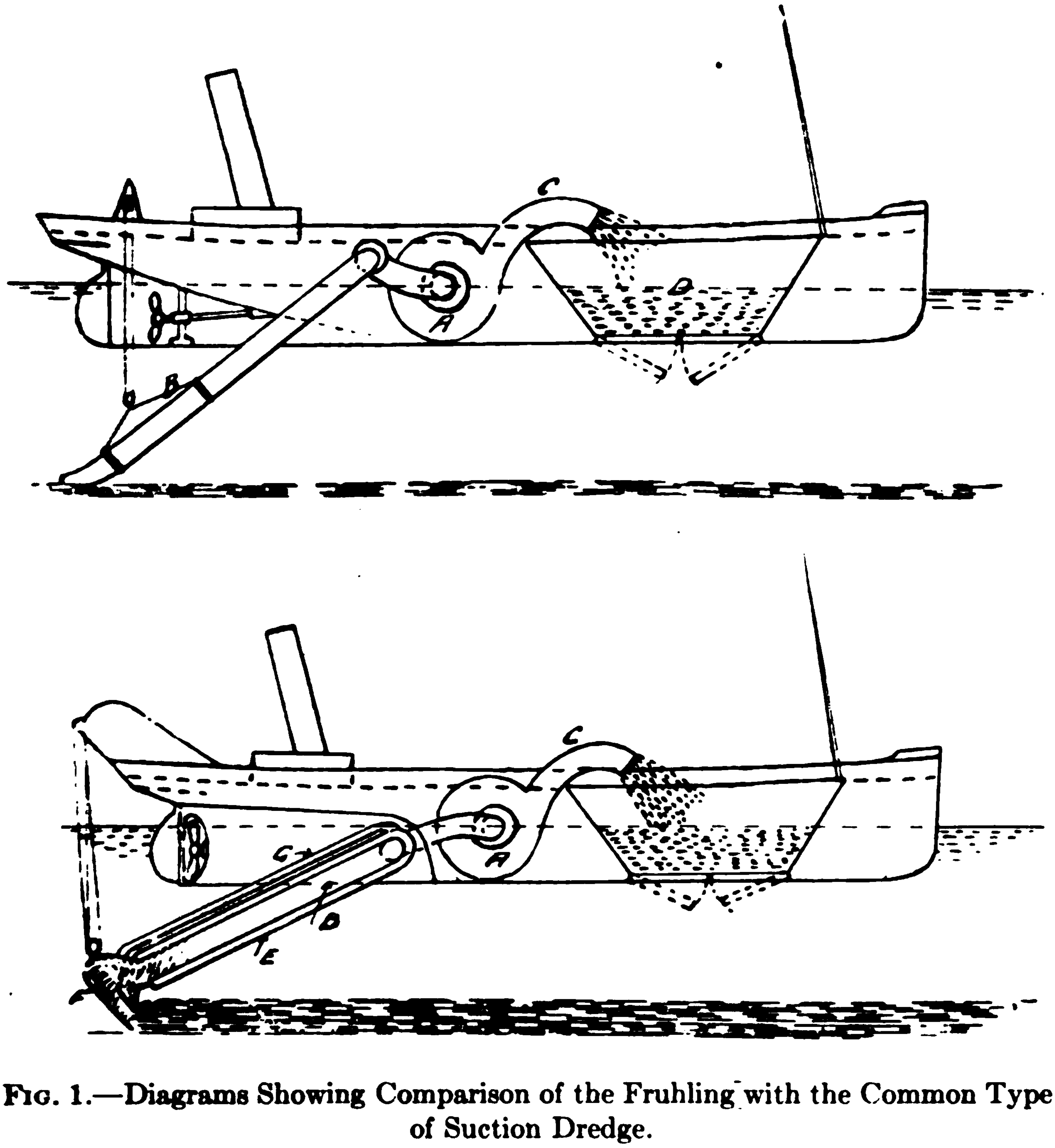



FIG. 1.—Diagrams Showing Comparison of the Fruhling with the Common Type of Suction Dredge.

evident, as one would expect, that the working efficiency is exceedingly low. It is a fair statement that in ordinary sand dredging this type of dredge rarely obtains an average of 15 per cent. of useful work out of the total work done. To put it otherwise, from 10 to 15 cubic yards of sand is the usual quantity secured from every 100 cubic yards of water and sand passed through the pumps. What would be thought of a steam-shovel which could lift only 15 per cent. of its bucket capacity each trip, and which lost a good deal of each shovelful in loading the dump car? That type of shovel would have a short existence; but so cheap has the work of the suction hopper dredge, with all its defects, proved in practice that the mechanical defects and inefficiency have been treated as more or less inherent, and largely ignored. The reason for the low efficiency of the ordinary form of dredge is not hard to find. By no possible exercise of ingenuity can the intelligence of the dredge master or his crew be put in control of the suction entrance in this type of dredge. If the material is hard packed, no amount of pumping will bring up the solids; if the material is soft, one may pump a big hole where the suction happens to be, and possibly have the estimate reduced by the inspecting engineer for cutting over depth; if the dredge is in a tidal current or sea-way, the flexible pipes take charge of the situation entirely, and it has to be managed to suit them, or they are destroyed. At the hopper end there is, again, serious loss of efficiency because so much water has to be pumped which has to go back overboard, and if the materials dredged are light, they go with it, and the losses are enormous. Under the circumstances it is surprising that this dredge does as good work in sand as the records show.

When, however, one considers its work in mud and fine silt the efficiency, which is low enough in sand, becomes very much lower. This is not because the mud cannot be drawn into the suction water, but because it cannot be taken out again in the hopper. By no known means can mud be precipitated from a thin solution in any period of time for which a dredge master would be willing to stand. Take a familiar example: how long must one wait after stirring up the mud in a pool till the water is clear again, which shows that the mud has been deposited? Much longer certainly than any dredge captain could afford to wait and hold his job, and one must remember that in the ordinary dredge the hopper is in a perpetual turmoil from the enormous volume of water which the pump discharges into it,—a condition which simply precludes any precipitation of the mud

to compel suitable sand (of which, by the way, there are infinite varieties) to flow in a 60 per cent. solid stream into the hopper. But in ordinary working from 30 to 40 per cent. of sand in the discharge is more usual. This you will notice is from three to four times as efficient as the ordinary form of dredge. The reasons for such a large increase in efficiency are evident at a glance. The suction end of the pipe is no longer left to the freedom of its own will. It is under the absolute control of the dredge master. It cannot balk or shirk its work; the hopper discharges betray its every failure. Anything in the way of free materials, sand, mud, gravel, even clay, that comes in way of the ponderous head has to come up. If the ground is soft, it is immediately responsive; if there is an incrusted surface, as there often is with sand, it is immediately destroyed by a furious application of water jets controlled by the dredge master, which issue from and into the head in a veritable maelstrom, the result reminding one of hydraulic mining as practised in the west, or the Seattle habit of sluicing their hillsides around the town. It is precisely the same principle, with precisely the same results. No material but solid rock can withstand the pressure of the water jets, and in the Fruhling head there is, in addition, a great plow or rake that cannot be resisted, while the pump suctions finish the work.

The first real Fruhling dredge—*i. e.*, not experimental—was the "Nicolaus," built for the German government for use at the Elbe entrance to the Kiel Canal. The Elbe is of the same nature as the Delaware; it deposits mud, in places where it is particularly undesirable, in unlimited quantities. Big bucket ladder dredges and a fleet of steam hoppers could not keep down the deposits, which threatened to choke the whole canal entrance. With length of only 153 feet, a hopper capacity of only 520 cubic yards, and a single 16-inch centrifugal, the "Nicolaus" clears up the mud and removes it two miles to dump at the rate of 6000 cubic yards in the ten-hour day. The 520 cubic yards can be filled in from twelve to fifteen minutes, giving a pumping capacity per hour of nearly 1500 cubic yards after deducting percentages for water contained in material and in the hopper. The percentages of solids pumped vary from 80 to 90 per cent., the bottom being thin, soupy mud. Such results were simply a revelation, and created new records in suction dredge work.

They are recorded in the following certificate from the late Herr Scholer, Chief Engineer on the Kiel Canal:

"This is to certify that the dredge 'Nicolaus,' in the Emperor William Canal, has dredged in 700 working hours 1,350,000 tons of sand, mud, and silt, and has transported and discharged this material for a distance of 1.5 miles in 1450 hours. The average cost of the above work (including transport) was three-fifths of a penny per ton (1.2 cents).

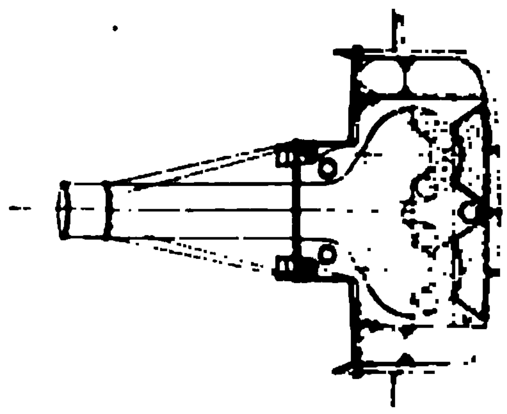
"After carefully watching the work done by the 'Nicolaus' I am able to say that, in my opinion, the Fruhling system is the most reliable, economical, and effective system of maintenance dredging I have seen.

(Signed) "SCHOLER,
"*Chief Engineer of the German Government of Kiel Canal.*"

The Fruhling dredge is the maintenance dredge *par excellence.* It is a marine channel scraper, or, to use another simile, a submarine vacuum cleaner, and it clears the channel as fair and true as a plane leaves a plank. It cannot cut holes and overdepths and it cannot undermine banks and quays by ill regulated suction effects outside of the head, because there are none.

The success of the "Nicolaus" was so pronounced that it resulted in an order from the German government for one of the largest and most powerful suction dredges that had been built to that date. See Figs. 2 and 4. This dredge, known as No. VII, was required for the cutting out of the great North Sea Naval Station of Wilhelmhaven, which now harbors the German North Sea fleets. It is a 2000-yard hopper dredge with two 24-inch centrifugal pumps, 2000 I. H. P. engines, and a speed when loaded of ten knots. The pumping capacity in mud was found to be over 5000 cubic yards per hour, and in sand over 2000 cubic yards. Such a demonstration of efficiency in rough sandy ground had not previously been approached. It may be said that this large type had to carry its hopper load more than 8 miles to dump, but owing to the saving of time in pumping a load, it was able to do so at a marvelously low cost rate.

Orders have been executed recently for Fruhling dredges for Germany, England, China, Japan, Canada, Belgium, and the International Danube Commission. Brief reference will be made to the Belgian and the Danube Commission's vessels, which are among those most recently constructed, and which illustrate further developments in the Fruhling system. The method in common use on the Delaware is to dump the dredgings from scows and dredge hoppers into the river and to re-pump again by a pipe line dredge on to the shore behind bulkheads, and thus to utilize the dredgings for



...ne material dredged
...this work in the Kiel
...ack into the water the
...ny another dredge to
...ment; in fact, this is a
...plan, with nothing to

...a self-discharging arrange—
...tral hopper pipe concealed
...ter branches to the hopper
...ng outside water to dilute the
...to pump after standing, and
...der pressure any block of ma-
...n pipes. The hopper contents
...hopper pockets with the dredge
...through a deck pipe connected
...on the quay alongside or on a
...In this way no material is lost
...rehandling dredge is needed, and
...ngly rapid, rarely requiring more
...say, from fifteen to twenty minutes.
...which had to operate exclusively in
...by pumping only, and the hopper
...this seemed at first a somewhat bold
...that, as an incidental result, a gain
...per cent. has been obtained. This is
...ttom being water-tight, which hopper
...has to be made in calculating the hopper
...the hopper after load is dumped.
...into a practically dry hopper and
...water in the hopper.

...Commission ordered a large vessel 230
...hopper capacity, two 24-inch centrifugals;
...alongside one of the most powerful bucket
...which was, after the arrival of the
...would deal with all the sand and mud), rele-
...of clay and other materials not usually con-
...dredge work. As, however, banks of clay
...and mud, it was decided to try the "Dimitri
...was called, in this material. After numer-

nvolving various changes in the dredge head, a form ch enabled the clay to be handled at a rate exceeding f the bucket ladder vessel. The form of head was ıual, perfectly smooth in the interior, studded full r-holes to form lubricating areas, and with guard n jets over the suction exits from head to prevent lace.

n of the Fruhling system has failed if the members ve not been impressed with the possibilities of the elphia. What, in a word, is the situation which elphia as regards the Delaware River channel? hat a 30-foot channel from Philadelphia to the sea 'ement, and reflects credit on the men who planned ctors who executed the work. But the question is, oot channel? The answer appears to be that it no 'act, Philadelphia's great trade route is threatened; ıroat is in the grip of an insidious enemy, the well- ʼil." It will surely not take reports of many more ısports, battle-ships, or ordinary tramps to convince ng is seriously wrong. The report of the army en- oposed 35-foot project must convince any one that The channel of the Delaware is exposed to rapid the formation of mud shoals of enormous extent ...f is only obtained by costly dredging; diking the channel is simply out of the question. Money which might be used for increasing the depth of the channel must be spent to secure a precarious hold on what depth there is now—a hold so precarious that there is uncertainty of even retaining it. Instead of having 30 feet of depth at low water, it does not now appear certain that there is a depth of 24 feet. The situation is serious, and calls for immediate treatment. Can any port prosper when it is falling rapidly behind neighboring ports in its ability to handle ordinary sizes of modern tramps, not to speak of the liner or the battle-ship? This, in a word, is the question facing Philadelphia to-day, and reference is made to it only because there is a solution to the problem of channel maintenance in the Delaware River.

There are two features to this problem:

1st, The lifting of the material from the channel.

2d, The disposal of the material after lifting.

As regards the first feature, it may be said that it is a matter of

So that this experience has led to the passing of laws which make it a misdemeanor to deposit any material within the high-water mark of the Delaware or any navigable river; even the dumping of ashes from tug-boats is prohibited by law. There is good reason for this, and the mere suggestion of adopting a plant of this kind to clear the Delaware would, I fear, meet with strong opposition by people who have made these discoveries from long experience.

By the improvement of the Philadelphia harbor some ten or fifteen years ago there was deposited north of the present Delaware River bridge of the Pennsylvania Railroad, in what was considered a pocket between the Jersey shore and the other side, a very hard sand or gravel; it was poured some distance from the Jersey shore, and in this pocket the water was considerably deeper than it was on the bar. Still, with this advantage in favor of the dump, it was only a short time before a survey showed that the material was no longer there, and the question arose, where was it? The channel shoaled up, and there is no doubt but what a great deal of it found its way back to the channel. Of course, no one could prove that this was precisely the same material, but the fact remains that the channel shoaled up.

Therefore, the standard of economy seems to be to adopt a dredge of this class, to use the very good suction appliance that this dredge possesses, and deposit the material thus sucked up into scows of large capacity, say perhaps a thousand yards apiece. Again, to have a sufficient number of scows to keep the dredge practically busy during twenty-four hours, which would mean in addition a tug-boat plant of probably two, four, or six boats, depending upon the size of the dredge. Of course, the relative proportions can be worked out by taking into consideration the time in which the tug-boat would be able to return with its tow of scows and the amount of material the dredge could take out when working constantly during twenty-four hours.

I suppose no one will doubt that the greatest economy in an operation of this kind is produced when the machinery is constantly in operation. The interest on the money invested continues day and night and Sundays, and the expense of additional forces required to operate a dredge at night, or on different shifts, is not sufficiently great to overbalance the interest loss or time loss if the plant is operated only a part of the twenty-four hours. It will take perhaps two tides, or may be three tides, to deposit the material for a distance of 60 or 70 miles, the tug-boats working with the tide, taking a long tow and going down-stream with the tide on the ebb, and coming back afterward on the flood tide with the light scows, which has been found to be a great advantage in a tidal river.

E. H. Rigg.—I cannot claim to be a dredge specialist, and in these days of specialization the outsider has to be careful how he trespasses on another man's ground.

From the paper, data, and pictures there is no doubt as to the efficiency of the Fruhling head, and the simplicity of the idea goes far to establish its claim.

In a recent issue of "International Marine Engineering," a series of articles on dredges appeared, so that this paper has been read at an opportune time; but, more important still, several meetings have been held in this city lately to urge a 35-foot channel for the Delaware. The latest battle-ships draw close to 30 feet in salt water, and well over that figure in fresh water, to say nothing of any extra draft caused by damage received in action; how, then, could a damaged "Florida"

before, it is a long haul in the case of the Delaware River—70 miles—which would mean that it would take a tug-boat say half an hour to load and a day to make the trip, which shows a loss in the use of the plant.

On the other hand, the use of steam hoppers, which was suggested as being economical—more so than scows—would make it necessary to use a crew for each boat, which means an engineer, a fireman, a captain, probably a mate and a deck hand or two, a cook, and others, while in the case of a tug-boat it would require only one crew which can haul five to ten times the amount of material that one of these hoppers can haul. It would probably result in less speed, but not as little as one-fifth of the speed, and considerably more than one-fifth of the speed of the other, and therefore would be more economical, saving the wear and tear and depreciation of the machinery of one of these steam hoppers compared with the scows, and their expense of operation and first cost would be greater.

A. M. Loudenslager.—When Mr. Taft, now President, came back from Panama, he made a very glowing report about the success of these dredges. I made some comparisons of that report and the performance of the present dredge now operated in the Delaware. Much to my surprise, upon taking up item for item, I found that the dredge "Delaware" was doing just as good work as was claimed to have been done in Panama.

A dredge was built in Philadelphia, and tested on the Delaware, which afterward made a trip of about 15,000 miles to the Columbia River, carrying its own coal.

The capacity of the dredge "Delaware" is about 3000 cubic yards, and we fill these bins in twenty-two minutes; that is, with mud and water; what percentage is mud is demonstrated afterward. We keep going continually; that is, say, we start out to-morrow (Sunday) night, and work twenty-four hours a day until next Saturday. If we had to haul, say, down to Ship John, 60 or 70 miles, it would be simply impossible to do this; we have to put the material ashore. It is necessary to have some sort of a re-handling plant or pumping machine which will lift the mud and take it away, after it is taken out of the channel, and get it ashore.

Mr. Reid.—In regard to the clearing up of the Delaware, I do not want you to assume that I have but taken a look at the Delaware River from the quays, and that I am going to give you in five minutes a solution of a problem which has baffled the best talent in this country for many years. I have made myself familiar with the reports of Major Deakyne and others; the report of Major Deakyne is one of the most remarkable documents on dredging which I have seen up to the present date. Therefore I can talk with some authority on this subject.

I agree with your President that there is no necessity to tow the material 70 or 80 miles to sea, and you would not think of towing it with a Fruhling dredge, or any other dredge; there are many Delaware fills that have been built, and I know that you have many artificial fills into which you can pump dredgings, if you have the machinery.

The "Delaware" is a splendid dredge, but she cannot get the stuff out of her hopper again, except by dumping. The Fruhling dredge pumps her stuff out alongside of the fill. Where there is a channel with millions of cubic yards of mud in it, the main thing is to get it out as soon as possible. You must get the mud

PAPER NO. 1088.

# AN AUTOMATIC SIGNAL FOR ELECTRIC RAILWAYS.

CARL P. NACHOD.
(Active Member.)

*Read May* 21, 1910.

IN track circuit signaling for steam roads it is usual to place the signal indication, as the semaphore, at the insulated track section, which is the beginning of the block. The engineman of the train enters the block if the signal shows clear, and does not look behind him after passing to see that it has gone to danger to protect the rear of his train. Such a signal indication would ordinarily be a two-position one, in which the absence of the danger signal constitutes the safety signal. The apparatus to work in this manner must be of the most perfect design possible and the inspection and maintenance of the same quite thorough and expensive. In fact, a report recently made public shows that on a road having over 100 semaphore signals the maintenance has figured about $100 per signal per year.

These signals are operated from a track circuit in which the only insulation between the two rails is that of the wood ties and ballast. The pairs of rails are separated into signaling blocks by means of insulated joints. At one end of the block there is connected a relay consisting of an electromagnet with an armature which, when attracted against gravity, holds a pair of contacts closed. At the other end of the block a low voltage battery, two gravity cells in parallel, is connected across the two rails. There is thus a closed circuit formed through the rails, the battery, and the relay magnet, the rails being of opposite polarity. The relay magnet is continuously energized when the block is clear, that is, with no train on it. In the circuit of the relay contacts is the signal-indicating mechanism, operated by an independent local battery, the mechanism being arranged so that the signal indicates clear only when current flows in the circuit, and drops to the danger indication when this circuit is interrupted. When a train enters the insulated track section, the train wheels form a shunt path of very low resistance relative to that of the relay magnet, which is therefore deprived of current and drops

used on steam roads, an equivalent safety can be produced by well-designed contact devices, resulting in a much simpler signal installation.

The system brought to your attention is intended to prevent head-on collisions on single-track electric railways where cars run both ways on the single track. It has three indications: neutral, proceed, and stop. The neutral—meaning, presumably, clear—may be changed to proceed in the sight of the motorman after he passes the contact device and before passing the signal indication. He therefore becomes responsible for setting his own signal and does not proceed until he is aware that he has set it. With this arrangement the signal indication must be set a sufficient distance ahead of the contact device to enable the motorman to see the indication both before and after passing the contact device.

The electric circuit of the permissive or proceed indication is completed through that of the danger or stop indication in the distant box, and the display of the former is therefore an assurance that the latter, the main signal, is displayed.

When the motorman approaches the single-track block from a siding or turnout, he observes the signal indication before reaching the trolley contact switch. If this is neutral, it means that the block is clear. After running under the contact switch he observes the change made by his car in passing it, and if the permissive signal shows, he passes the box and enters the block. The permissive or proceed indication is given by an opaque white color disk and a white light at the same time, making a combined day and night indication. While a semaphore, which is an arm pivoted so as to show sharply defined positions against the sky, is probably the best signal aspect as regards visibility, it is not used in this case because it is too vulnerable for any but private right of way; and besides it requires an excess power to drive, on account of rust, snow, and ice due to exposure to the elements. The day signal is therefore an enameled aluminum disk adapted to be withdrawn or exhibited before a glazed opening in the signal box. When the motorman sees the permissive signal, a white light and a white disk, he knows that the danger signal at the other end of the block is showing to prevent a car from entering against him. This signal also consists of a red light and a red disk displayed simultaneously. An electric light alone for a day indication is unreliable, for with a combination of low voltage and direct sunlight it is almost indistinguishable. But the conditions that are

Fig. 5.—Elevation of Signal Box

The curve p in Fig. 6 shows the variation of magnetic pull with diameter of pole face for magnets of the same type, having the same external dimensions, stroke, and heat loss in the coil. The rectilinear motion of the plunger is well adapted for making contact by sliding, and the bearing surface and consequent durability of such a plunger magnet is much greater than that of the pivoted armature type.

The entire relay, including both switches and coils, is immersed in oil in a tank which hangs independently from the upper case. This is a construction new in signal work and conferring a number of benefits, among the mechanical ones being continuous lubrication of moving parts, the prevention of corrosion, and cushioning of the violent magnet blows. Electrically, the oil suppresses the arc at the contacts, keeps the coils cool so as to increase the range of current through which the relay is operative, obviates burn-outs, improves

FIG. 7.—Trolley Contact Switch from Above.

FIG. 8.—Trolley Contact Switch from Below.

the insulation of parts, permitting of a very compact design, since the live parts may be brought closer together than in air, and also minimizes damage by lightning.

The trolley switch (Figs. 7 and 8) consists of a light metal framework for holding two longitudinal inclined contact strips in such a relation to the wire that the wheel will touch the wire and one or both of the strips, which are electrically connected, but insulated from the trolley wire. The cold rolled steel contact strips are flexible in themselves and flexibly mounted through phosphor-bronze springs; but they are provided with positive stops to limit the deflection. It is a very delicate matter to attempt to restrain or touch the light trolley wheel moving at high speed, and the utmost flexibility of the contact-making device is requisite. When it is considered that a car running at 60 miles per hour will traverse a foot in approximately

trolley wires throughout, as is customary on some roads, is an advantage as giving a choice of location for the contact switches.

There are cases of car operation, however, where with D turnouts, *i. e.*, having one side of the turnout straight and the other offset, cars running either way will keep to the straight track if there is no car to be passed; and this will require a single switch that will set or clear the signal according to the direction of car. Fig. 12 shows diagrammatically a means of accomplishing this by dividing the contact strip longitudinally into halves. In conjunction with the reversing relays, this switch will act selectively to set or clear according to the end first reached by the wheel. Furthermore, by following out the

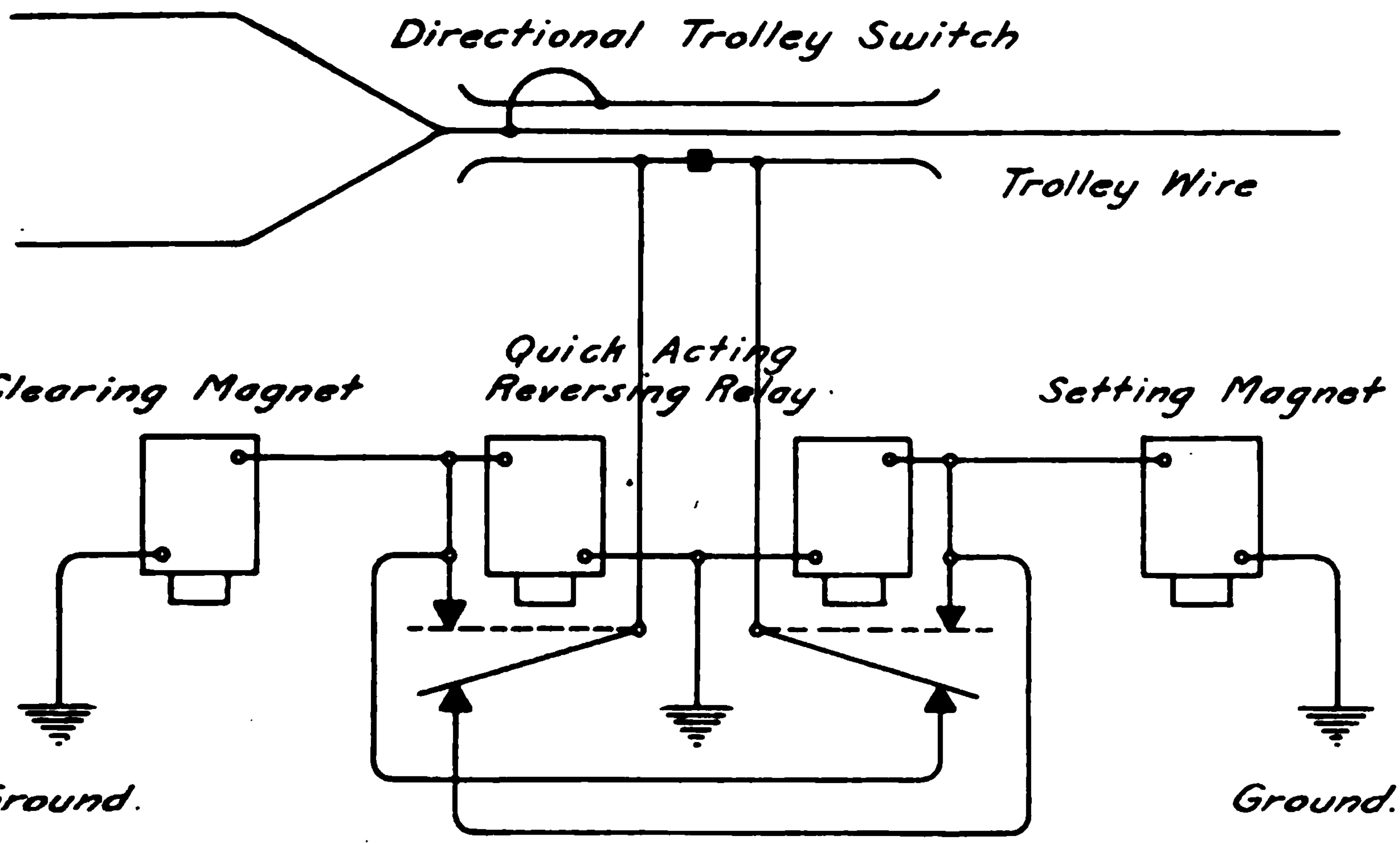


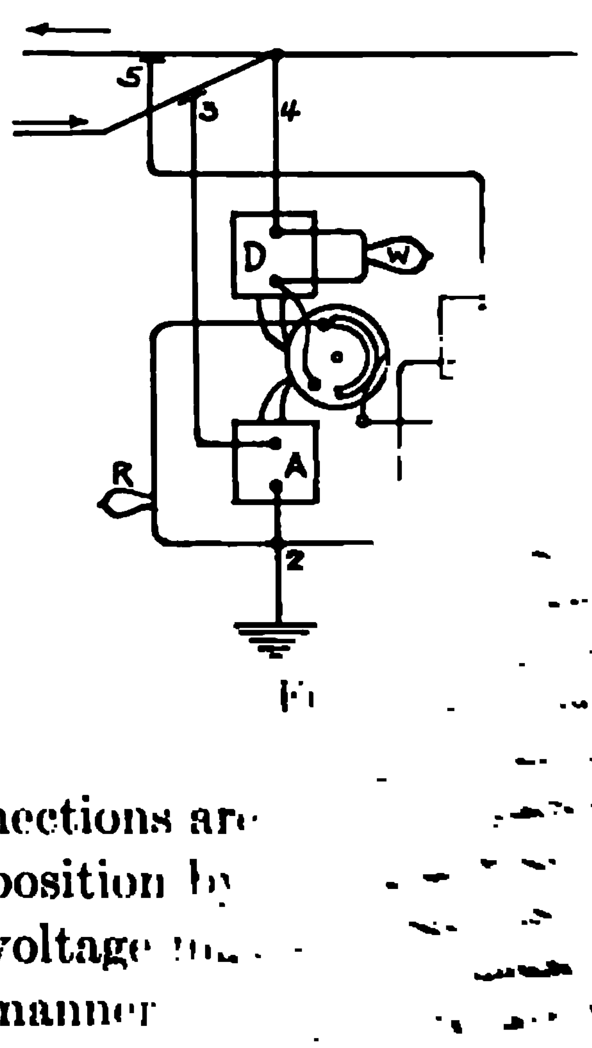

FIG. 12.—Connections for Directional Trolley Switch.

connections it can be seen that the total length of the switch—and not one-half only, as might appear at first sight—is utilized in forming the contact. The scheme is electrically analogous to having a finger hanging down over the wire struck by the trolley wheel so as to make either of two contacts according to direction of the car. It is, however, effected without moving parts in the contact switch, which, owing to its location, is not easily accessible for inspection and maintenance.

## DISCUSSION.

E. J. DAUNER.—If the lamps should burn out at night, what provision is there for signalling?

case each end of the signal wire is groundo...
With no current in the coils, armatures dr...
sends an impulse of current through m...
entering end, operating a two-way revo...
that end of the signal wire to trolley t...
magnet, D. This light and the red ...
in series through the signal wire. S...
revolving switch so that the conta...
change in the electrical circuit. ...
C to break temporarily the signal...
in the first relay to drop its arm...
reverse direction. When the...
made on the magnet C as on...
entered the block have left...




Fi...

nections are...
position by...
voltage ...
manner...
the p...
In ...
sen-...
sig...
ca...
a...

...s independent, the
...e headlight of the
...at night, the system
...lse indications.
...system rendered safe?
...e signals will be given.
Should a car attempt to
...is inert, the signals can-
...ained by that car.
...regularly should enter the
...of traffic; would the signals

...it would work properly; but
...course, be two of these switches,
...that the car entering under either
...under either of them would clear
...car entering and backing out under
...two cars. This may be corrected,
...switch, located on the same pole, as
...under the entering switch.
...ssible for a succession of cars going in
...the signals set always in one direction,
...one direction for a long time?
...conceivable. They are covered by the
...objection to permissive signaling which
...

...lightning have, and do you find it
...choke coils?
...installation of lightning arrestors spaced five
...signal line wire, and we have not found choke
...of the relay, by its high insulation, seems to
...lightning. In case the relay is injured from
...that if the stop signal does not set, neither can

...customary to inspect the signal systematically,
...of doing so?
...reports of cases where nothing has been done to
...time. Unfortunately, they often have to get
...inspection, but I think they ought to have a thorough
...every two months. We know that the oil does not
...there, the mechanism cannot rust. We have no
...inspection.
...you incorporate an automatic stop if the motorman
...where is the signal in operation?
...would probably be incorporated in the system, although
...at present. For instance, there might be an electro-
...which would throw the wheel from the wire when
...signal. The signal is in operation in about thirteen differ-

, Spokane, Washington; Los Angeles,
Youngstown, Ohio; in Orange, N. J.,
mpany, in Waterville, Maine, and a
Rapid Transit Company has adopted
'ay
nt of the extreme flexibility of your
ns of sleet in a storm might render it

the contact strips are partly covered
ons to be recorded; but if the switch
act can be made and no permissive

ie weight of the sleet bend the strips

e itself would hardly stand such an
ı before that time At any rate, the
its deflection.
ppen if the insulation on the trolley
iould be short-circuited?
witch, the signals would stay set for
t were the clearing switch, the signals
s equivalent to opening the line wire,

League, and since 1884 has been a member of the Engineers' Club of Philadelphia.

No synopsis of the activities of Mr. Converse would be complete that did not refer to his continued and earnest devotion to the Presbyterian Church, of which body he was a member and in the councils of which he rose to a prominence paralleling his attainments in business pursuits.

In 1873 Mr. Converse married Elizabeth Perkins Thompson, of New York. He leaves one son and two daughters, also an adopted daughter, his wife having died in 1907.

While the foregoing incomplete summary of his numerous affiliations apparently precludes the idea of repose, Mr. Converse always seemed to have time to spare, and none who sought his counsel was ever turned away unheard. Though modest and unassuming in manner, he was firm as a rock in maintaining his convictions, and although his views might not coincide with those of others, he always impressed the persons with whom he came in contact of his earnest determination to obey the command "to do justly and to love mercy and to walk humbly with his God."

He was an untiring worker, and a practical optimist who had confidence in the future and believed in the ultimate advent of better conditions, and so he worked cheerfully and well.

The world has need of men like John Heman Converse. We revere his memory and realize with sorrow he is no longer here.

The Committee on devising ways and means for improving the Club-house presented its report, and, after discussion, it was ordered that the Board authorize the immediate obtaining of a loan of $8500 on a note secured by individual indorsements.

It was moved and carried that the $8500 loan provided for be expended in whole or as much as may be necessary for improvements, and that the amount of the loan be kept in a separate account, payments to be made on the architect's voucher and countersigned by the regular officials of the Club. It was ordered that projected improvements be strictly limited to the amount of $8500.

It was moved and carried that a sum of $850 be set apart annually in a separate fund, to meet the interest on the loan, and to provide a sinking fund for its retirement. Messrs. Hess, Plack, and Vogleson were appointed a Committee to secure the $8500 loan.

Upon motion of Mr. Swaab, Mr. Plack was appointed architect of the Club in charge of the projected improvements.

Adjourned Meeting, June 9, 1910.—Present: President Easby, Vice-President Christie, Directors Cochrane, Develin, Plack, Swaab, Hutchinson, Mebus, Worley, the Secretary, and the Treasurer.

The Treasurer presented a report showing the present financial condition of the Club, and, following this, it was ordered that the President and Treasurer be authorized to renew the existing loan of $1500 at the Colonial Trust Company for thirty days, and to borrow an additional $1000 for thirty days, if it appeared to them necessary.

The resignations of George H. Benzon, Jr., H. C. Felton, James C. Newlin, E. Collins, Jr., and J. Edward Whitfield were accepted as of even date.

The Committee on Improvements to the Club-house presented a report, stating that means had been found for raising the $8500 loan to be spent on improvements to the Club. On motion, F. K. Worley was added to the Committee appointed to secure this loan.

It was ordered that a Committee of three be appointed by the Chair to study the By-Laws and present to the Board definite recommendations for changes therein.

# THE ENGINEERS' CLUB OF PHILADELPHIA

1317 Spruce Street

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## OFFICERS FOR 1910

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*President*

WM. EASBY, JR.

*Vice-Presidents*

*Term Expires 1911*
JAMES CHRISTIE

*Term Expires 1912*
HENRY HESS

*Term Expires 1913*
CHARLES HEWITT

*Secretary*
W. P. TAYLOR

*Treasurer*
J. A. VOGLESON

*Directors*

| *Term Expires 1911* | *Term Expires 1912* | *Term Expires 1913* |
|---|---|---|
| H. P. COCHRANE | EDW'D S. HUTCHINSON | DAVID HALSTEAD |
| R. G. DEVELIN | CHARLES F. MEBUS | E. J. KERRICK |
| H. E. EHLERS | S. M. SWAAB | PERCY H. WILSON |
| W. L. PLACK | A. C. WOOD | F. K. WORLEY |

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### STANDING COMMITTEES OF BOARD OF DIRECTORS

*House*—W. L. Plack, H. P. Cochrane, P. H. Wilson, A. C. Wood, F. K. Worley.
*Meetings*—W. P. Taylor, Chas. Hewitt, A. C. Wood, S. M. Swaab.
*Membership*—Chas. Hewitt, James Christie, Chas. F. Mebus.
*Finance*—James Christie, H. E. Ehlers, Henry Hess.
*Publication*—Chas. F. Mebus, R. G. Develin, J. A. Vogleson.
*Library*—H. P. Cochrane, Edward S. Hutchinson, H. E. Ehlers.
*Publicity*—David Halstead, S. M. Swaab, W. P. Taylor.
*Advertising*—H. E. Ehlers, E. J. Kerrick, R. G. Develin.

### MEETINGS

*Annual Meeting*—1st Saturday of February, at 8.15 p. m.

*Stated Meetings*—1st and 3d Saturdays of each month, at 8.15 p. m., except between the fourteenth days of June and September.

*Business Meetings*—When required by the By-Laws, when ordered by the President or Board of Directors, or on the written request of twenty-five Voting Members of the Club.

The Board of Directors meets on or before the 3d Saturday of each month, except June, July and August.

Editors of other technical journals are invited to reprint articles from this journal, provided due credit be given the PROCEEDINGS

# PROCEEDINGS
OF
# THE ENGINEERS' CLUB
OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.



Vol. XXVII. OCTOBER, 1910. No. 4

PAPER NO. 1089.

## SUBMARINES.

SIMON LAKE.
(Visitor.)

*Read March* 19, 1910.

WHEN the United States Government in 1893 advertised for inventors to submit designs for the construction of a submarine torpedo boat, it is doubtful if a "corporal's guard" of officers in the United States service could have been found that had any faith in this type of vessel.

The submarine boat at that time was considered as great a curiosity by the majority of people as the flying machine was previous to the public flights of the Wright brothers a little more than a year ago. At that time neither the United States, England, Russia, nor any of the European countries were in possession of what might be termed a practical submarine vessel.

The French Government had one experimental vessel in commission, called the "Gymnote," and another under construction, which was called the "Gustave Zede." The latter was launched in June, 1903. Both these vessels were of the diving type, and operated on the same principle as numerous others that had been experimented with during the nineteenth century.

The records show that nearly a hundred submarine boats have

"The horizontal rudders and the regulating cylinders acted much too slowly. Most frequently they had to resort to the donkey pump or to air-pressure to expel water, but then the ascension would take place very violently, and when at the surface, the vessel would be found to have a buoyancy of several cubic meters. A vertical screw was therefore fitted to regulate the motion up and down; it was worked by hand. In this way the equilibrium under water was kept, but only for a very short time."

The result of the experiment was that it was possible to make a submarine boat slide along the bottom in the way described above, and also to move steadily awash.

It will be seen from the above description, and the abandonment of the vessel, that this boat, like many others of the type, was unmanageable when attempts were made to run her in a submerged condition. With her shallow depth and great beam it is probable that the failure of this vessel was largely due to a lack of longitudinal stability, which stability, in the speaker's estimation, is the first and most important thing in the designing of a submarine vessel.

The Confederates attempted to use the submarine boat during the Civil War and succeeded in sinking one of the United States warships. They called the little submarine boats which they constructed at that time "Davids," and the name was a most apt one. The next war will probably prove that the submarine "Davids" will be able, like David of biblical fame, to destroy the great "Dreadnaughts," or Goliaths, of the present day.

Previous to the beginning of the nineteenth century some experiments had been made in the construction of submarine vessels. The first important one of which there is any record was constructed in the seventeenth century by Cornelius Debrell, a Dutchman, who lived in England during the reign of James I. Nearly a hundred years later a man by the name of Day built a submarine and made a wager that he could descend to a depth of 100 yards and remain there twenty-four hours. He did, and according to latest advices, is still there.

The most authentic information at hand, however, regarding the early submarines, is of a boat built by a Connecticut man, Dr. David Bushnell, who lived in Saybrook during the Revolutionary War. He built a small submarine vessel called the "American Turtle," with which he expected to destroy the British fleet anchored off New

In the spring of 1801 he took the "Nautilus" to Brest, and experimented with her for some time. He and three companions descended in the harbor to a depth of 25 feet and remained one hour, but he found the hull would not stand the pressure of a greater depth. They were in total darkness during the whole time, but afterward he fitted his craft with a glass window 1½ inches in diameter, through which he could see to count the minutes on his watch. He also discovered during his trials that the mariner's compass pointed equally as true under water as above it. His experiments led him to believe that he could build a submarine vessel with which he could swim under the surface, and destroy any man-of-war afloat. When he came before the French Admiralty, however, he was met with blunt refusal, one bluff old French admiral saying: "Thank God, France still fights her battles on the surface, not beneath it," a sentiment which apparently has changed since those days, as France now has a large fleet of submarines. After several years of unsuccessful efforts in France to get his plans adopted, Fulton finally went over to England and interested William Pitt, then chancellor, in his schemes. He built a boat there, and succeeded in attaching a torpedo beneath a condemned brig provided for the purpose, blowing her up in the presence of an immense throng. Pitt induced Fulton to sell his boat to the English Government and not bring it to the attention of any other nation, thus recognizing the fact that if this type of vessel should be made entirely successful, England would lose her supremacy as the "Mistress of the Seas."

Fulton consented to do so, but would not pledge himself regarding his own country, stating that if his country should become engaged in war, no pledge could be given that would prevent him from offering his services in any way which would be for its benefit.

The English Government paid him $75,000 for this concession. Fulton then returned to New York and built the "Clermont" and other steamboats, but did not entirely give up his ideas of submarine navigation, and at the time of his death was at work on plans for a much larger boat.

Fulton had a true conception of the result of submarine warfare, and in a letter he says: "Gunpowder has within the last three hundred years totally changed the art of war, and all my reflections have led me to believe that this application of it will, in a few years, put a stop to maritime wars, give that liberty on the seas which has been long and anxiously desired by every good man, and secure to

buoyancy was so reduced as to present a very small target. This enabled them to manœuver the boat sufficiently near the "Housatonic" to prevent discovery until too late to ward off the attack.

The author was fortunate enough several years ago to receive a visit from Mr. Charles H. Hasker, of Richmond, Va., formerly Lieutenant of the Confederate ironclad "Chicora," stationed in Charleston Harbor. While experiments were being made with the submarine vessel just described, Mr. Hasker volunteered as one of the crew for the experimental trip about the river, and was one of four that escaped when the vessel went down. He gave me the following account of her sinking:

"The submarine had a line fast to the steamer 'Etawan,' off Fort Johnson; the crew were all in their places, and had started the craft ahead. The buoyancy of the vessel had been reduced so that only the hatch combings were above the water. The side submerging vanes were operated by a tiller connected with the athwartship shaft, and were held in a horizontal position by means of a stick of wood placed beneath. When the vessel started ahead, Lieutenant Paine attempted to cast off the line which was made fast around the hatch combing. He became entangled in the line, causing the boat to sheer slightly and careening her sufficiently to permit the water to come in the forward hatch. The Lieutenant, in his struggles to extricate himself, struck the prop which supported the ends of the tiller, thus causing it to drop to the floor and forcing the forward ends of the vane downward. This, of course, immediately pulled the bow of the boat under water." Mr. Hasker occupied the forward seat just at the hatchway. Lieutenant Paine succeeded in getting out as soon as he saw the boat was going to sink, and Mr. Hasker grasped the edges of the hatch combing and finally forced his way through the column of inrushing water, which was, by this time, coming in with great force. But before he was entirely out of the opening the pressure of the water closed the hatch door, which caught his left leg below the knee. The pressure of the water was so great against the door that it crushed the muscles of the leg, and held him in this position until the vessel had reached the bottom in seven fathoms of water. The hull then being filled with water, equalized the pressure so that he was able to lift the door, and being an expert swimmer, he swam to the surface. The boat went down head-first, and before the after hatch got under water, two other men succeeded in escaping, the other five being drowned.

one well adapted for giving great stability, but was not suited to speed. It was largely due to Baker's success, however, and to the report made by a board of officers which watched the performances of this craft in 1892 that the first appropriation of $200,000 was made for the construction of the United States submarine. When the appropriation was made, Baker was so sure of receiving the award for the contract that he moved from Chicago to Washington with the idea of being close to the Government authorities while developing the plans for his large vessel. He died shortly after moving there. Mr. Holland, Mr. Baker, and the author, it is believed, were the only inventors of submarine craft that were present with plans in Washington at the opening of bids in June, 1893. The author did not submit a proposition to build a vessel, as the advertisement stated that the department would consider designs even if they were not accompanied by tenders for construction; and if the designs were considered meritorious, the department would itself arrange for the construction of the vessel. The author's designs were submitted to a board to pass upon their merits, and he was later advised by the late Admiral Matthews that his designs were looked upon with considerable favor by some of the members of the board at that time, but as the Holland designs were accompanied by a bid to construct, with a bond for performance, and backed by a company, the Navy Department was reluctant to take upon itself the responsibility of the development of a vessel from designs only. The matter of awarding a contract was held in abeyance for over a year, and finally the award was made to the Holland Company for the construction of the "Plunger" on certain guarantees of performance, which guarantees were destined never to be fulfilled under the first contract, as this boat, the "Plunger," was to have done many things that even to this day have never been accomplished by any submarine boat. She was to have a speed of about 16 knots and be able to go from light condition to that of complete submergence in twenty seconds. Her construction extended over a period of several years, and she was finally abandoned in 1900, after the Holland Company had received additional appropriations and brought out a much simpler vessel in the "Holland," the first United States submarine torpedo boat which went into commission.

The following cuts show some of the earlier submarines, as well as the more recent and successful boats now in the possession of the most important navies.

model was pulled. The tank was so constructed that the water could be driven by the model at a constant velocity by the use of propellers; the velocity of the stream could be increased or diminished as desired.

This view shows a model of the "Protector" submerged, being tried out in this tank. The wave line at the surface is plainly shown. The stream lines are also plainly shown by the use of black threads, many of which were secured to a rod by one end, the other end being free. The rod could be moved to any desired position and the stream lines observed as they passed over, under, or to either side of the model.

The model was free to move up or down, a transverse shaft running through the model at a point half-way between the centers of buoyancy and gravity; wheels were fixed to the outer ends of this shaft. These wheels ran up and down on vertical wires on either side of the model.

On the reserve buoyancy being reduced in the model to about that used in the full-size boat, the hydroplanes would cause the boat to submerge or emerge on a level keel, in the same manner as the full-sized ship. It was found that with a certain inclination of hydroplane the vessel would submerge to a certain depth and automatically maintain that depth as long as the velocity of the stream was fairly uniform. To go deeper required a greater angle of hydroplane or horizontal rudder. Just why a vessel will submerge only to a given depth with a certain angle of hydroplane is not altogether clear. At the time these tank experiments were made this fact did not impress itself on the author's mind as much as it has since, due to some recent trials with one of our foreign boats, which was submerged with a reserve buoyancy of about 600 pounds. When first submerged, it was running with an inclination down by the bow of about 1 degree. The boat ran for thirty minutes, maintaining a constant depth of between 31 and 32 feet, without touching either the horizontal rudder or the hydroplanes. It was then noticed that the boat had changed her trim for 1 degree down by the bow to 1 degree down by the stern, which was gradually increasing. Still the boat maintained her uniform depth. A movement of 1 degree of the horizontal rudder brought her to a level keel. When she showed a tendency to submerge further, 2 degrees less inclination to the hydroplanes brought her back to her original depth with head of periscope about 1 foot above the surface, and she ran thirty minutes more without touching

as the vessel gathers headway, the water piles up over the cigar-shaped bow, which, combined with the increased frictional resistance due to the streams passing under the hull, causes the bow to submerge, and the vessel plunges toward the bottom. A cross-section parallel to the surface, through the hull near the bow as she is diving, would show (if she was moving forward at the same time) that there would be a tendency to create a vacuum under the forward portion of the vessel, which would tend to increase the inclination, and she would continue to dive until a sufficient inclination and depth was reached whereby the greater head of water at the bow reduced the

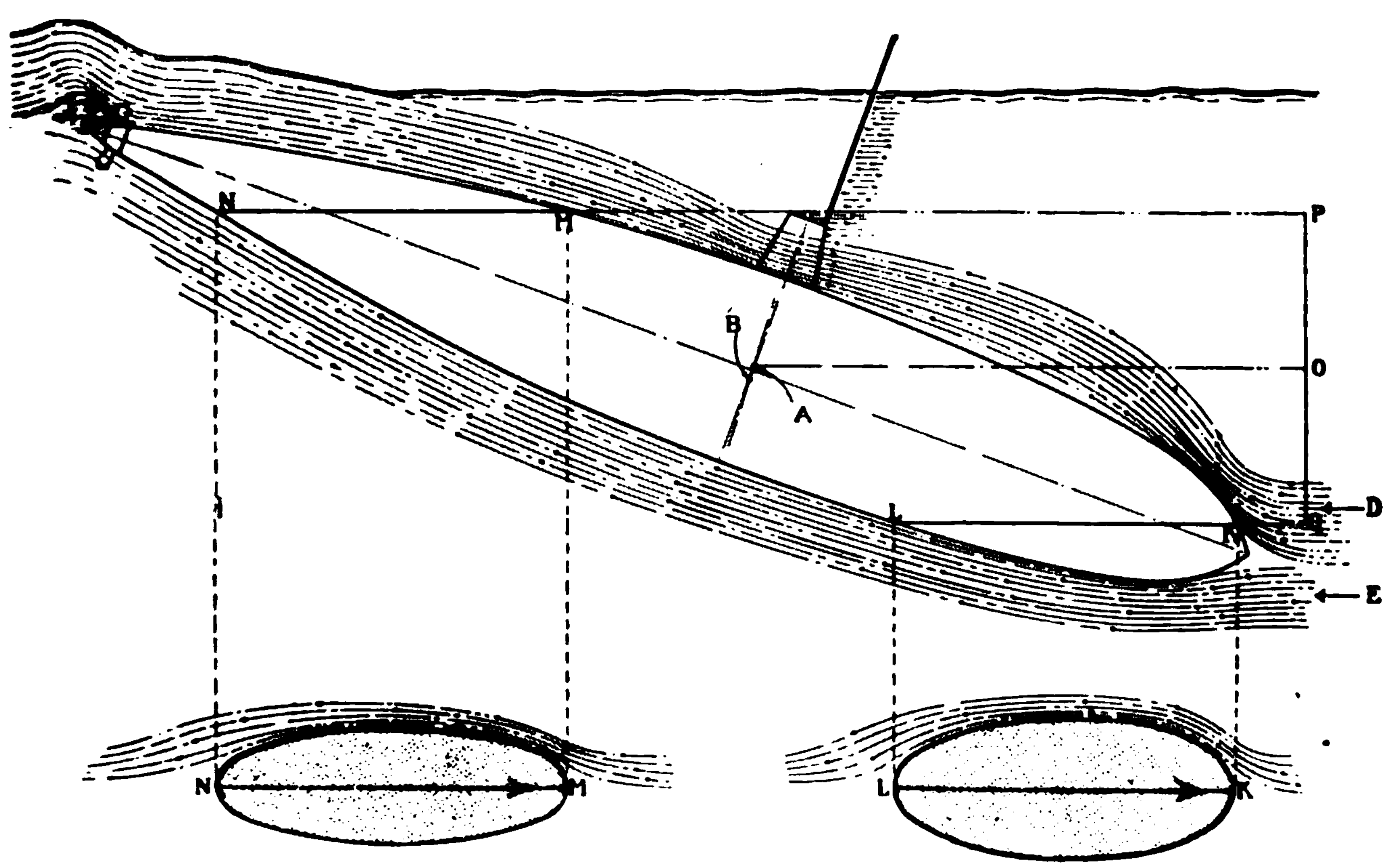


FIG. 8.

vacuum and consequent down pull on the bow, and at the same time the vacuum formed under the stern was proportionately increased, which, combined with the righting effect of the pendulum arm (her metacentric height) caused the forces to be reversed, and she would broach to the surface. The motion of the model would apparently synchronize, and the plunge toward the bottom and return to the surface again would occur with the regularity of clock-work. The obvious remedy for this tendency in a boat of the cigar-shaped form is to increase the metacentric height and the size of the control rudders and to keep in constant touch with the horizontal rudder.

States has the advantage of getting competitive bids, the requirements are as severe as, if not more so than, those of any foreign government.

The difference between a horizontal rudder and a hydroplane is this: A horizontal rudder is placed at the bow of the boat or at the stern and has simply a guiding function, to direct the course of the vessel up or down. The hydroplanes pull the boat up or down bodily, as it were. In the "Lake" type of boat they have always been equally distributed, one an equal distance forward and another an equal distance aft of the center of gravity, so that the forces acting upon them tend to force the boat down bodily on a level keel, and they also lift the boat on a level keel. With a horizontal rudder, one must change the whole angle of the boat itself, while with the hydroplanes one instantly gets down pull or up pull.

Air is compressed in steel bottles. Under the present government requirements, all submarines must provide for a certain number of cubic feet of air up to as much as 2500 pounds per square inch. The United States Government made a number of trials in 1907 in which the "Fulton" and the "Lake" both remained submerged for a period of twenty-four hours. Mr. Lake had previously made experiments in 1897 to determine how long a crew could remain submerged living on air in the boat alone without drawing in an outside supply. The "Argonaut" was only 36 feet long, and was for a period of five hours submerged without drawing on any air-supply from outside. Eight men at Newport in the "Lake" remained for twenty hours under water without drawing on outside air, at the expiration of which time the air was getting a little thick, and Mr. Lake noticed that some of the men were losing interest in things about them. He had been observing the condition of the air by watching a lighted candle, measuring the height of the flame of the candle both at the top and at the bottom of the boat. In this way he could judge if carbonic acid gas was forming. He would repeat this test every hour, and after they had been submerged fifteen or sixteen hours he noticed that the flame began to diminish, which was the first indication of bad air. At the end of twenty hours it was impossible to keep the candle lighted. About that time the men began to get sleepy and to breathe rather heavily; some fresh air was then admitted from the storage bottles. The pumps were started and pumped the foul air out from the bottom of the compartment and the fresh air was admitted at the top; the candle flame then immediately brightened. They then remained for two hours longer, until the candle flame began to show signs of getting weak again, when they repeated the pumping operation and remained for another two hours, and so on. When they came to the surface, they immediately got under way and went back to Newport, and none of the men suffered any bad effects.

Boats have electric heaters and cooking is done with electric apparatus; the crew lives aboard some of the boats altogether.

The French Government has been the most industrious in trying to use heavy oils for fuel for engines; in fact, abroad a number of Continental firms have been experimenting with the Diesel engine and have met with considerable success within the last few years. One government has proposed changing its gasoline engines for heavy oil engines, so well was it satisfied with their performance. Alcohol has not the same power as gasoline. When one attempts to provide a fuel which reduces power and speed, governments do not want it, so it looks

PAPER NO. 1090.

# NOTES ON THE DEVELOPMENT OF THE MODERN IDEAS OF THE FORM AND POSITION OF THE EARTH.

HENRY LEFFMANN
(Active Member.)

*Read April* 16, 1910.

To write the history of any science, or even of any phase of scientific, religious, or political movement, involves several difficult duties. It seems as if one might apply to the task the form of dilemma by which a Greek philosopher argued that motion is impossible. He said: "A body cannot move in the place where it is, and it cannot move in a place where it is not; therefore, it cannot move at all." History cannot be correctly written by contemporaries of the events because they are too near to some of the occurrences and too much influenced by the passion and personal relations of the period, and it cannot be properly written by successors, because they are too far away to appreciate all the influences that determine the course of events.

Nevertheless, men will busy themselves with the history of the past, as well as of their own times, and with guessing at the future course of events, and under such an influence the author has taken up the task of indicating some of the points in the history of geography and astronomy which have been concerned in the development of the present generally received views as to the relations and shape of the earth from the crude and erroneous notions entertained by primitive man. An exhaustive treatment of this subject would require a good-sized volume and an elaborate study of authorities. The present paper is merely to set forth a few steps in the course of events. It must not be overlooked that some difference of opinion still exists among experts as to the exact form of the earth, some regarding it as slightly pear-shaped. Among the unlearned in civilized communities there are a few who still believe the earth is flat.

For many years it has been the custom of those writing on any theme of ancient history to turn first to the Greek and Hebrew

when the transcriber is honest, involves liability to error, and the significances of words change in time, so that, for example, no person can now read Shakespere intelligently without an elaborate commentary. The view one gets of the ancient world through the existing manuscripts, inscriptions, and traditions is comparable to Darwin's view of the value of the geologic record as an aid to the study of biologic history.

With these reservations as to the trustworthiness of the available sources, the author presents some of the data collected on the subject.

While evidence is now at hand to show the great antiquity of man, civilization, in the sense in which the term is commonly understood, dates back, as far as is known, only a few thousand years. References are occasionally made in the newspapers to civilized states of ten thousand years ago, but these figures are untrustworthy. It is, however, no longer permissible to doubt that the high development of life in Egypt and Babylonia dates back several thousand years before the founding of Rome. It is important to notice that the conditions at this remote period, as far as one can make them out, were not rude or half civilized, but a complex life, comparable in many respects with that of the most advanced nations of the present day. It may, indeed, be said that while the modern world has much more knowledge than the ancient, it has little more wisdom.

The Babylonian and Egyptian records now at hand show the oldest civilization known. The literature of those lands had a profound influence upon the literatures of Palestine and Greece, though to what extent is a matter of much dispute among the experts. The material has not been presented in such a form as to permit the general reader to judge of its value, or to give much information as to the views held by these ancients on the subjects under present discussion. In those days learning was largely, if not entirely, in the hands of persons who carried on the religious teaching. It is generally believed that the Babylonian and Egyptian priests observed the movements of the stars and had theories as to the arrangement of the universe. They recognized the distinction between the fixed and wandering stars. In a later period the Greeks applied to the latter the term "planet" ("wandering"), and this name has been retained in modern astronomy. At a very early period the lunar and solar cycles were recognized, and rude predictions of eclipses and occultations could be thus obtained. By this means also the calendar could be adjusted. The prediction of eclipses would greatly impress the mass of the people,

The Babylonians and Jews appear to have regarded the earth as a fixture in the universe and the sky as an attachment to it. The phraseology of the Hebrew text suggests this, and if one goes into the etymology, one can elucidate the matter further. The word "hashamayim," translated "heaven" in the English bible, is probably derived from "shama," which means "high." "Ha" is the definite article and "im" is the sign of plurality, so that the translation "In the beginning God created the high places and the earth" seems to give a meaning more nearly akin to that which the ancient writer had in mind than the modern translation "heaven," with its concomitant notion of the abode of deity and associated spirits. Similarly, the word rendered "firmament" is akin to a word meaning "rolled" or "spread out," conveying the notion that God spread out the substance of the high places.

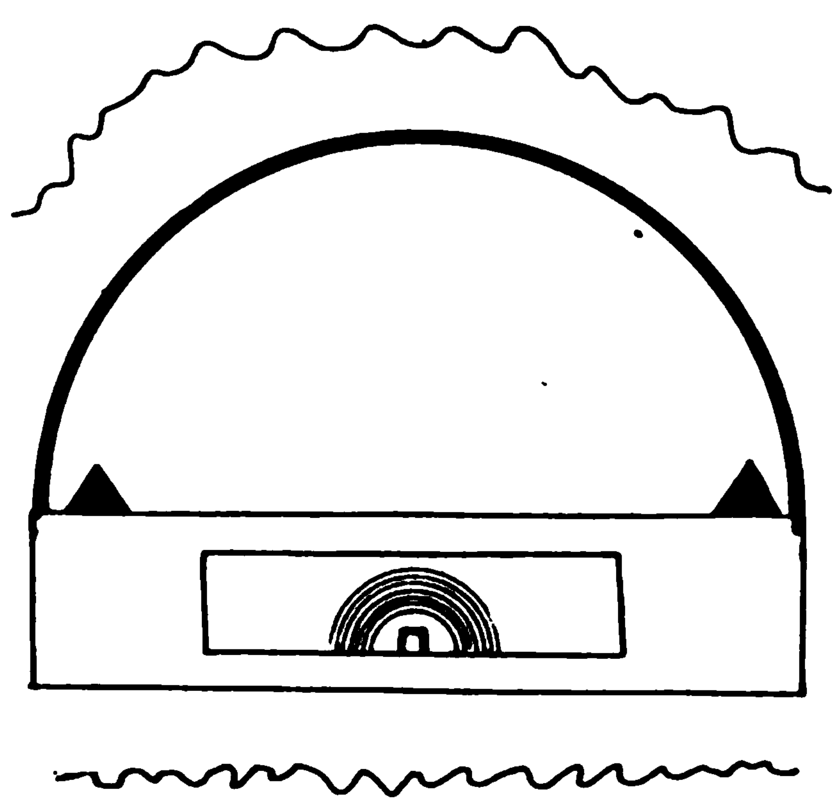

FIG. 1.—Babylonian conception of universe, adapted from Jensen, showing sunrise and sunset mountains, seven-walled abode of the dead; firmament, with waters above; waters under the earth

A graphic representation of the Babylonian theory of the universe is given by Peter Jensen in his work, "Die Kosmologie der Babylonier," from which the author has made a rude copy (Fig. 1). Jensen represents the surface of the earth as curved, but I think it more accurate to represent it as flat. By examining the text of Genesis, in the light of Jensen's picture, it is possible to construct rudely a representation of the universe as conceived by the Jews (Fig. 2), but it must be borne in mind that it is unlikely that either of these nations actually drew such pictures as are here shown. In the Jewish picture the attempt is made to show especially two of the meteorologic features, namely, the "fountains of the great deep," and the "windows of heaven." In Genesis vii : 11 the description is that at the beginning of the flood "were all the fountains of the great deep broken up and the windows of heaven opened."

These pictures must be regarded as suggestive only, but it is now

compared with present ones, the Greeks were the only scientists of antiquity. They alone felt the influence of nature as the manifestation of materialistic forces; they alone subjected all phases of knowledge to searching investigation. Their known history does not go back nearly as far into the past as that of the oriental nations, and they probably derived their language, much of their religion, and some of their fundamental ethical and philosophic doctrines from the orient, but they transformed all this material and brought out of it much that was new.

The Greek philosophic literature of the seventh, sixth, and fifth centuries before the Christian era is unfortunately only known in fragments, principally as quotations in the writings of later authors, one of whom, Aristotle, was essentially hostile to their views. It appears that materialists of the present day could shake hands over the interval of two thousand five hundred years with the early Greek thinkers. The discussion of philosophic theories did not lead to the recording of much astronomical data; at least, none has been handed down; so one is not able to determine the exact views of these pioneers. It is stated on good authority that in the seventh century B. C. Thales predicted an eclipse, but he may have been in possession of records that showed the approximate periods of recurrence.

Anaximander (580 B.C.) was one of the first to teach that the earth is free in space; it appears that he regarded it not as spherical, but rather flat-cylindrical, that is, drum-shaped. Pythagoras (about the same date) and his followers taught the sphericity of the earth. Anaximander is said to have made the first map, but this can only apply to Greek history, as some very early Babylonian and Egyptian maps have been found. It is doubtful if Herodotus accepted the theory of the sphericity of the earth, but Aristotle taught it. How far the doctrine was accepted outside of the philosophic circle it is impossible to say. The ancient philosophers concerned themselves but little with the proletariat and slaves who formed the bulk of the working class.

The Romans were too busy conquering the world and attending to the government of it to develop the sciences to any great extent, and they took much of their knowledge and methods from the Greeks. Pliny the elder, in his work on natural history, is very positive as to the sphericity of the earth, devoting a chapter to arguing that there may be antipodes, adducing such facts as the observed curvature of the sea and that drops of water on a dusty surface assume a

PAPER NO. 1091.

# CONSTRUCTION OF A RAPID TRANSIT RAILROAD IN RELATION TO THE HANDLING OF PASSENGERS, AS ILLUSTRATED BY THE HUDSON AND MANHATTAN RAILROAD.

J. VIPOND DAVIES.

(Visitor.)

*Read June 4, 1910.*

PASSENGER transportation has developed the most complex problem which is to-day presented to the engineer for solution. The immense increase of population, particularly with reference to the concentration in cities, has produced new and grave conditions which have to be cared for by a careful study of individual cases, as each case requires absolutely new and independent treatment. With the steam railroads the problem of handling passenger traffic remains very much as it formerly did, except that with the extension of cities into their suburban districts the local traffic has become so much heavier that the distribution of passengers from the terminal destination introduces a new and serious problem. The number of persons who desire an all-the-year-round residence in the country districts, and who conduct business within the cities, is becoming yearly greater, and is only made possible by improved transit facilities being provided. This condition has also become a considerable factor in increasing the taxable values of suburban real estate and in developing real estate in the suburban districts of the great cities. London and New York offer the best illustrations of this condition, as in each of these cities, there is a small district of limited area in which the bulk of the business is transacted, and a huge territory, radiating in every direction, where the business people have their residences. The state line between New York and New Jersey is a fictitious division; and, eliminating all consideration of the boundary-line between these two states, there is a district tributary to New York City which has a total population of over 6,500,000 persons.

the cheapness with which they can be constructed, or in order to obtain what is called rapid transit service at a reasonable cost, in districts sparsely populated. This has been deliberately done with the present Rapid Transit Subway in the city of New York, where, in the northern portions of the city, the subway emerges onto an elevated structure and runs over long sections of steel viaducts. To a considerable extent the same has been done in Philadelphia. If any such structures are necessary and are hereafter built, they should be carefully designed and constructed so as to eliminate all noise arising from an exposed light steel structure. This may be accomplished without any great addition in first cost, and with only slightly increased obstruction upon the surface of the ground.

The title which has been adopted in this country for transportation other than on the surface has an unfortunate adaptation, as it involves a good deal of service which is by no means "rapid transit." The service to which these or any lines of public transportation are applied is affected materially, first, by the density of the population, and, second, by the local conditions. At the same time it is readily understood and appreciated that the service is the heaviest at certain hours of the day and lightest at other hours, and, curiously enough, it seems that on most lines the traffic curves correspond very closely; that is to say, granting a certain total daily service given by any line of railroad, whether on the surface, on ferries crossing the rivers, on an underground, or steam railroad line which does a local transportation business within our populous areas, the curves of traffic per hour are very similar, varying, of course, according to the total movement per diem. These curves reach their summit, or peak, in the morning hours in the movement toward the heart of the city between 7 and 9 o'clock, and reach the corresponding peak for the evening outward bound movement between 4.30 and 6.30 o'clock. The Public Service Commission has rather happily designated these movements as "workwards" and "homewards" respectively. The morning peak in one direction, workwards toward New York, reaches its maximum between 8 and 9 o'clock, 7½ per cent. in the direction of heavy flow, and in the opposite direction simultaneously 1½ per cent. of the entire total traffic in both directions per twenty-four hours; while the homeward peak in the evening—the heaviest and controlling movement—reaches its maximum between 5 and 6 o'clock, when the outward movement is 10.7 per cent., and the simultaneous reverse movement 2½ per cent., of the entire total traffic in both directions

tion must be done with a clear knowledge of the fact that one is dealing not with individuals but with masses or crowds; and while the individuals composing the mass have sense and can be reasoned with and managed, the mass is unreasoning and often unreasonable; consequently nothing can be omitted in the design and equipment of a transportation line which will assist and direct a crowd so that it can have no possible choice in the matter of what it will or will not do. Only by perfect arrangements in this respect can the railroad and its operating officials obtain the best results for the traveling public. To obtain best results has been the constant effort of those who have had to do with the development of the Hudson and Manhattan Railroad.

The original inception of the present system was a tunnel between the foot of 15th Street, Jersey City, and the foot of Morton Street, New York, which had been started many years ago. The Company had undergone several reorganizations, and the property was finally acquired by the present holders at a foreclosure sale. The property then consisted of a section of a tunnel, of considerably larger internal diameter than the present tunnels, driven from the New Jersey shore toward New York. It was designed and partially constructed with the idea of being a terminus to be used jointly by the Erie and Lackawanna Railroads, and while the construction of this short section made history in engineering, considering that the promoter was really not an engineer at all, the use and operation of it were utterly impossible. The portion of tunnel constructed was 18 feet internal diameter, unnecessarily large for the ordinary street railroad or suburban railroad car, but too small for two cars to pass, and yet the tunnel was designed for a standard steam railroad car, for which it was unsuitable. In the first financing it was most essential to get a tunnel under the river to demonstrate the feasiblity of its construction, and after the long history of failure which had attended the early days of the Hudson River Tunnel Company, it was desirable to establish the fact that such a railroad could be built and operated. A plan was therefore prepared by which it was contemplated that the tunnel would be carried to the New York shore of the same diameter as the portion driven from the New Jersey shore, and within this tunnel it was proposed to operate very narrow cars, somewhat along the lines of the cars first operated in the City and South London Railroad tunnel in London. The tunnel was to be equipped with double tracks and operated as a double-track railroad, in order that it might be of

surface and trolley lines of the Public Service Corporation of New Jersey from the north end of Hudson County terminate, and where the Lackawanna Railroad brings a large suburban traffic over its lines. When the first tunnel was connected under the river to New York, application was made to the Rapid Transit Railroad Commission for authority to change the location of the terminus in New York, for which the earlier franchise had been obtained, to a point where it would be of real service to the public as well as an objective point for operation. The result was the location of the terminus at Sixth Avenue and Thirty-third Street.

Such is the brief history of the development of the Hudson and Manhattan Railroad, and it may be of interest to present various points which have been carefully studied, considered, and adapted for its particular business and special needs, whereby the company has endeavored to carry out arrangements which place this road, it is believed, ahead of all others that have been installed in combining convenience and ease of operation with the least possible friction and discomfort to the traveler, and with the greatest possible efficiency and economical handling of traffic.

*Capacity.*—The first essential in the study of this railroad was to decide definitely on the capacity for transportation that could be furnished during the hour of maximum travel, as this factor is the basis for regulating everything that comes after. The dimensions of the property which could be acquired for stations, either downtown in New York or at Hoboken where it was necessary to locate upon private property and not under the public streets, fixed the greatest length of train that could be accommodated at 400 feet. The curvature of the railroad as laid out, particularly the short curves (radius 90 feet) entering and leaving the Church Street Terminal, made it necessary that the cars should be as short as possible and the truck centers so spaced as to reduce the overhang of the cars on curves to a minimum. The cars in the Rapid Transit Subway in New York are 52 feet long, but this length proved to be too great for the Hudson tunnels, as an eight-car train would be in excess of the maximum length of train that could be accommodated on a tangent in the stations. After considerable study the length of car determined was 48 feet 3 inches when coupled, with distance between truck centers 33 feet. All clearances in the tunnels and approaches had, therefore, to be figured in relation to this particular size of car. The clearances in the tunnels allow for a car of the same width as the original subway

station and tracks of the Pennsylvania Railroad. At Hoboken arrangements previous to this had been made for the occupancy of the under-surface of property of the Public Service Corporation at the point where its trolley system terminates near the ferry; and fortunately this location was adjacent to the Delaware, Lackawanna and Western Railroad station, so the use of this private property fixed the station at this point. The tunnels extending from Hoboken to the Pennsylvania station pass under the property and yard of the Erie Railroad, so a station was located at Pavonia Avenue for the interchange of passengers with the Erie Railroad and also with the trolley cars of the Public Service Corporation. These points practically control all the local street railroad business of Jersey City and Hoboken as well as the great bulk of the steam railroad business coming to New York.

In New York city uptown the local conditions make it necessary to have stations at close intervals to give proper facilities to the public and to connect with the intersecting street railway lines, elevated railroad lines, etc. It was undesirable to locate stations, even for local business, closer than 1200 to 1500 feet, which makes but a short distance for passengers to walk to or from intervening points, and if the stations were located closer than 1200 feet the trains could not gain sufficient speed between stations to give adequate service. In the case of Hudson and Manhattan Railroad the stations, except on Sixth Avenue, are few and at long intervals. The distance from Church Street to the Pennsylvania station is 1.25 miles, from Hoboken to Christopher Street 2.01 miles, and from the Pennsylvania station to Hoboken, with only one intermediate stop—Erie Station—is 1.75 miles; consequently very fast service can be given.

Having decided upon the general location of the stations, the next point was to determine upon a design for stations with a view of providing every facility and convenience for the traveling public. When a railroad has to provide facilities for handling a concentrated travel of 32,000 passengers per hour in one direction, and when that volume of traffic is likely to have one point as its destination, as, for instance, Church Street Terminal, New York, and to a less extent the terminal at Hoboken, then the design of the station is all-important, and it is particularly important with respect to regulating the length of time of station stops, so as not to hamper operation and interfere with the regular maintenance of the prescribed train interval. Some years ago it was thought necessary by railroad men to have at a station

staircases to Dey Street provide free ingress and egress to and from the concourse floor.

It is not possible in all cases to load passengers so that they will be evenly distributed throughout the train, as is the case at Church Street terminal. For instance, at Hoboken terminal the only connection available for interchange of passengers with the Lackawanna Railroad is at the extreme easterly end of the platform, and naturally most of the passengers from the Lackawanna Railroad enter the first car they come to and fill the cars at one end of a train, leaving the cars at the other end practically empty. To counteract this unequal train loading an entrance for passengers interchanged with the Public Service Corporation (trolley cars) was constructed as near as possible to the other end of the station, and the result is a well-balanced arrangement for the distribution of passengers throughout the entire train. Similarly, at the Pennsylvania station passengers from the railroad are necessarily delivered to the Hudson and Manhattan Railroad at the extreme easterly end of the station, and to counterbalance this, entrances for passengers from the trolley cars and street are located at the westerly end of the station. The local stations on Sixth Avenue have all been arranged with entrances and exits as near as possible to the center of the train, whereas the stations at Christopher Street and Ninth Street, owing to curves in the line which prevented the platform from being centered on the only available site for a stairway and entrance, are arranged for end loading—Christopher Street at the westerly end and Ninth Street at the easterly.

In the design and construction of the stations of the New York rapid transit subway practically all the entrances and exits consist of openings in the sidewalks covered by kiosks, which interfere seriously with the use of the sidewalk. In the development of the Hudson and Manhattan lines the Rapid Transit Commission appreciated the objections to the kiosks erected on the sidewalks and compelled the company to arrange for the entrances and exits through private property unless specifically permitted to do otherwise by the Commission. In some cases arrangements were made for entrance and exit through private property on Sixth Avenue, and in other cases entrances and exits were placed under the stairways leading to the elevated railway, so that the erection of kiosks involved no additional obstruction on the sidewalk. To make a railroad of the greatest convenience to the traveling public, the stations need be clearly

defined and easy of access. An entrance through private property seldom affords the same convenience to the public as does an entrance direct from the public streets, even at the expense of obstructions such as railings or kiosks. Entrances placed directly upon the street are more in evidence, and are consequently of greater value to the public, so that although, at first thought, the obstruction to the sidewalk may be considered as preëminent, yet the general convenience of the traveling public is better served by kiosks. On the other hand, where it is possible to arrange stairways, as was done on the Hudson and Manhattan Railroad, under the stairs of the elevated railway, so as to provide this convenience without additional obstruction to the sidewalks, the arrangement is ideal. There is, however, one serious drawback, as in the majority of cases the stairways to the elevated railway are so narrow as to give inadequate width for proper service, and wherever there is a possibility of passengers moving in opposite directions no stairway should be installed less than five feet in width, and it is desirable to make them not less than six feet wide, which allows ample width for two persons abreast walking in the direction of the maximum movement and one person in the direction of contrary movement. The interference with the movement of passengers in the maximum direction by an opposite movement on narrow staircases is detrimental to general efficiency.

Platforms should be designed to provide ample room for the free movement of passengers. In the case of unloading platforms all that is necessary is to have sufficient space with ample exits, so that an entire trainload of people can be easily discharged onto the platform within the limit of time fixed for the station stop, and, further, that the entire trainload so discharged may pass out of the station before the arrival of the following train. It is usually not necessary for a platform to be wider than the floor area of the car itself, although there should be a widening of platforms in the vicinity of the stairways or exits, as there must of necessity occur a slight congestion at the points of exit from the unloading platform. In the case of loading platforms, the consideration is affected materially by the character of train service operated. With the Hudson and Manhattan Railroad at Church Street terminal, and later at the Thirty-third Street terminal, there are in use platforms 20 feet wide, common to trains serving different routes. There must, therefore, be ample room on the platforms for an entire trainload of people to stand for either route for which a train is destined and to distribute themselves so that

opportunity for those persons already having tickets to pass along. The arrangement of ticket windows in tandem on the same face is valueless, for the reason that those who are buying tickets at the first window must of necessity cross the stream of passengers trying to obtain tickets at the second window, which invariably causes discomfort and obstruction. The Hudson and Manhattan Railroad has carried out the usual arrangement of installing one large and important ticket office at a station in which the ticket agent can keep his safe, stock of tickets, and cash, and in addition has provided sundry portable ticket offices which can be wheeled into line during the busy hours and moved entirely out of the way during the slack hours. In all cases the arrangement of ticket offices should be such that the ticket-chopper is near to the ticket-seller, so that the seller may have the chopper under observation, and so that in case of necessity the ticket-chopper may assist the ticket-seller. However, the distance between the two should be such as to permit a passenger, after having purchased a ticket, to pause before putting the ticket into the chopping-box. One ticket-chopper usually serves two lines or streams of traffic, and the barriers should be only so wide as to allow a single file of passengers to pass on each side of the chopping-box. The most convenient and desirable width for this passage is 24 inches. With the ordinary stream of passengers on this road it is found that one ticket-chopper can pass through the gate in two files 108 passengers per minute. This rate of passage is too great, however, except for short spurts, as the chopper cannot properly examine tickets, and provision should be made for an average rate per chopper not exceeding 4000 persons per hour. An examiner who has to punch or personally scrutinize railroad tickets can only pass about 30 per minute. An ordinarily competent ticket agent will sell about 2000 rapid transit tickets per hour and make change, or for short periods may sell as many as 2500 tickets per hour. In calculating the number of selling agents or chopping-boxes necessary for handling the maximum traffic, these figures can be taken as a basis for speed.

In connection with the stations there is one other matter to which reference should be made: that is, the necessity for the use of elevators or escalators at certain points in the underground railroad where the depth of the station below the surface is considerable. The new plans of the Public Service Commission require them when the lift exceeds 30 feet. This is provided on the Hudson and Manhattan Railroad at the Pennsylvania station in Jersey City. The capacity

elevators can handle passengers at the rate of 60 people per minute in one direction. On one occasion five fully loaded suburban trains of the Pennsylvania Railroad, after being stalled at Point of Rocks outside Jersey City, came into the station practically in a procession, and the passengers moved into the elevators as they arrived without the slightest congestion or undue inconvenience. An elevator of the size installed at this station is probably more efficient for the rapid handling of passengers than one of larger floor space, as the service is so rapid that there is practically no pause in the flow of people.

*Cars.*—In handling passengers, the second important point is the design of car, particularly with reference to loading and unloading, and its internal arrangement as affecting the passenger, and its relation to the station. In the first place, the train service operated by the Hudson and Manhattan Railroad is essentially a short-distance service. The longest continuous distance usually traveled by a passenger—from Pennsylvania station to Thirty-third Street, or from Hoboken terminal to Church Street terminal—is less than four miles, consequently the time a passenger is in a car is comparatively short, and not comparable with the time taken on a railroad such as the electrified lines of the Long Island Railroad, or the Interborough Rapid Transit Subway, where a passenger may ride from 20 to 25 miles on a continuous trip. It is a well-known fact that a crowd of people desirous of traveling on a train will insist on using the first train in every case, and will jam itself into a train whether there is sitting room or not, notwithstanding that another train is following within ninety seconds, and in spite of the fact that crowding an already overloaded train materially lengthens the time of the station stops and interferes with the headway and progress of all following trains. The next following train may be running practically empty. It is, therefore, not essential on a road such as the Hudson and Manhattan, to attempt to provide the maximum seating capacity in a car, but it is necessary to give an adequate seating capacity only under ordinary conditions and at ordinary hours, and to give the greatest floor space, for standing room, and for carrying the maximum number of people in the easiest way with the least obstruction and inconvenience due to deliberate overcrowding.

The Hudson and Manhattan Railroad trains are essentially moving terminals for the steam railroads; a very large number of passengers carry valises and other baggage; consequently, the car with the

would be a very serious burden to maintain men on every platform to operate the side doors. On the Hudson and Manhattan Railroad all car doors are equipped with a pneumatic device for opening and closing, and there are air-cushions on the edges of the doors. No trouble whatsoever in the operation of the doors, and practically no accidents of a serious nature, have occurred. The Rapid Transit Subway has equipped the side doors of its newer cars with mechanical devices operating with a chain and toothed gears, which appear to operate satisfactorily.

Generally speaking, in rapid transit service the conditions are different from street railroad conditions by reason of the fact that on a street railroad passengers get on and off the cars and trains anywhere, and that fares are collected in each car at the point where a passenger gets on, which makes the entire distance the car travels practically a continuous station. In any rapid transit or high-speed line it is necessary to make definite stops at stations and to equip each station properly for the sale and collection of tickets instead of on the trains.

The greatest complication, in connection with a moving platform device, is in making it a continuous station. One of the points of advantage in a moving platform is the fact that the whole distance can be made a station, practically the condition on a street railway; but it is almost impossible to equip the whole length of the platform with ticket agents.

The capacity of trains is regulated, as before outlined, by the capacity of the cars forming the trains. The frequency is regulated by the time interval at which trains can be operated, and is irrespective of the speed of trains, which affects only the convenience of the public, and the ability of a railroad to get business. A railroad is a commercial enterprise, and while it is constructed for public service, it is primarily constructed with a view of obtaining an adequate return on the money invested. To obtain this result, therefore, on a private or public investment, it is essential to operate with the greatest efficiency, and to so design a railroad that it can give maximum service. Therefore the details presented here will indicate the importance of not sparing trouble or expense in designing, constructing, and equipping a railroad so as to give the greatest service with the least inconvenience to the traveling public combined with maximum efficiency and economical operation. The essential point with a public service corporation is to serve the public prop-

erly, and this was the underlying thought of Mr. McAdoo, the President, when at the opening of the Hudson and Manhattan Railroad he addressed the employees with words to the effect that he wanted no effort spared in the operation of the railroad to please the public.

If it is conceded that a rapid transit railroad is a public utility, then there is also implied a mutual obligation between those who operate the road, and the public authorities who grant franchises and regulate the service, to treat each other in a broad-minded manner, and to coöperate in providing rapid transit facilities which will be of the greatest service and convenience to the traveling public.

PAPER NO. 1092.

# A TRIP ACROSS THE ISTHMUS: LIFE AND CONDITIONS ON THE CANAL ZONE.

MARTIN NIXON-MILLER.
(Active Member.)

*Read April* 30, 1910.

OF all the difficult engineering problems of the present day, there is not one on such a great scale as that of digging the canal across the Isthmus of Panama.

The scheme of the canal was first thought of by a Spanish engineer named Saavedra, in 1517, one of Balboa's followers. This was during the reign of Charles V, King of Spain. Surveys were ordered, but the work was reported impracticable. Philip II, successor to Charles V, in 1567 sent an engineer to survey the Nicaragua route, who also submitted an unfavorable report. Philip then laid the matter before the Dominican monks, who, desiring to obey the king's orders, but being unable to report intelligently, searched the Bible and quoted the following verse as having direct reference to the Isthmian Canal: "What God hath joined together, let no man put asunder" (St. Matthew xix : 6). This was sufficient for King Philip, and the subject was dropped for two centuries after his death. In 1814 Spain once more considered this question when her Central and South American colonies obtained their independence; and all that can be said of Spain now is that she furnishes some of the best laborers on the canal; one Spaniard being equal to three negroes, and less troublesome. The negroes are English subjects from the West Indies. American negroes from the southern states proved very unsatisfactory, and but few remain.

The French began the canal in 1878, but owing to their failure in making good sanitary conditions, they died by the thousand. The machinery used by the French was the best that could be bought at that time, and some of it is now used to advantage by the Americans, although in design, speed, and size of units it is far behind the present standards. The principal point of excellence of the French

Sanitary Department, sickness is kept very low, as well as the death-rate. The Department even takes care to catch mice and rats, as these animals carry the bubonic plague.

At present there is a total of 36,900 Government employees, 6000 being Americans, the remainder consisting of sixty-nine nationalities, of which 25,000 are negroes and 4000 are Spaniards. To January 1, 1910, there were but 12 deaths per 1000, while in 1906 the rate was 65, and in 1905 it was 45. Thus it can be seen how carefully the Sanitary Department, which includes the hospitals, does its share of hard work in this great canal enterprise. The usual number of sick is now only about 30 per 1000, of which 22 per 1000 are negroes.

Tobago Sanitarium, built by the French, is used for the American and Spanish employees when discharged from the hospital. The time spent there is usually a week to ten days, and it is in the most delightful location in the tropics, situated 12 miles off Panama. There is less rain there than in Ancon. The best pineapples in the world are raised there. The patients enjoy good sailing and bathing. The Government takes care of the employees free of cost.

There is not a case of yellow fever, smallpox, or bubonic plague on the Zone.

*Temperature.*—Although within but a few degrees of the equator, the conditions are entirely different from what most people expect, owing to the belt of aqueous vapor which hangs over the Isthmus and permeates the atmosphere. The humidity is nearly always over 85 per cent. This is a very disagreeable feature at first, but, after becoming acclimated, it is preferable to the heat which would otherwise be felt.

During the rainy and dry seasons there is usually a difference of 15 to 20 degrees between day and night. In the rainy season the variation is from 65 to 85 degrees, and that of the dry season from 75 to 95 degrees. Owing to this change in temperature, and to the thinning of one's blood, a blanket is a necessary article for the Americans, and sometimes more than one is needed in order to be comfortable.

*Rainy Season.*—Although but forty-seven miles across the Isthmus, most of the rain falls on the Atlantic side, graduating during the year 1909 from 237 inches at Cristobal to 84 inches at Ancon on the Pacific side. As a comparison, New York, Philadelphia, Boston, Portland, and St. Louis had 40 inches, San Francisco 23 inches, Denver 14 inches, and New Orleans, 60 inches. Thus it can be readily understood what a rain is in the tropics, when all the above rain on the

Then, there is the little parasite known as the dhobie. This little fellow is invisible, and comes in one's laundry or shower-bath. He leaves his mud home to get under one's skin in the protected parts, and is the cause of an itch, known as the dhobie itch, to which every person is subject. Salicylic acid is the common remedy, but it causes the skin to parch, crack, and bleed. Maignen's antiseptic powder, manufactured by the Maignen Chemical Company, of Philadelphia, Pa., has been successfully used for relieving pain caused by dhobie itch, mosquito bites, ivy-poisoning, and jelly-fish stings.

Other annoying features are the red bugs, which bury themselves deeply under the skin and have to be dug out with the point of a knife, otherwise causing bad sores. In addition, there are the red and white ants, large flying roaches, beetles, sand-fleas, and sand-flies, to say nothing of the scorpions, tarantulas, and culebras. "Culebra" is the Spanish word for "snake." The most venomous is the coral snake. However, they are not often seen directly along the Canal, as all animal and reptile life has gone back to the jungle, owing to the noise from the train and blasting. The red ants are always busy doing good as scavengers, or else doing mischief by destroying plants and trees. It is because of these ants that vegetables, such as are raised in the states, are not cultivated on the Isthmus, except in a few places, where constant watching is required to make a success. This vigilance is too much for any native of Panama.

The white ant is very destructive, cutting its way into all kinds of wood, thus causing many a house to fall.

*Food.*—Food-stuffs are entirely cold storage and canned goods. Native fruits are not appreciated at first, except the oranges, bananás, pineapples, and grape fruit. The papias, mangos, alligator pears, and about half a dozen other fruits are sadly missed upon returning to the states.

Fresh meats can be bought, but a sight of the slaughter-house, the men handling the meat, and the dirty Spanish markets is sufficient inducement to let it alone.

*Game.*—Lots of fine sport may be had hunting deer, alligators, tigers or wildcats, and turkeys, but in this sport a nasty jungle must be traversed, stirring up snakes, scorpions, tarantulas, red bugs, and mosquitos. Upon returning from a hunt many a strong man has been taken with the Chágres fever, as a result of having been bitten by the mosquitos, which disease he might otherwise have escaped.

in the canal channel, as the set of the current is at right angles to the entrance of the channel, close to the shore. The building of this dike provides a place for disposing of the material from the cut south of Empire. North of Empire this material is used at Gatun Dam.

*Gatun Dam.*—No dam ever built has received more attention from the world at large than this one, principally because of its size. It is built between the hills of Gatun, through which the famous Chágres River flows to the sea. It consists of a core confined by rock walls. The core is composed of clay and sand mixed and deposited hydraulically. The dam rests on impermeable material of sufficient supporting power. It is 7500 feet long over all, measured on its crest, only 500 feet being subject to the pressure of 85 feet of water, and 3000 feet subject to the pressure of 50 feet of water. The width of the dam at the base is about 2000 feet, and the core at the base is about 860 feet. At the crest of the dam it will be 400 feet, and the height of the dam above the lake will be 30 feet with a width of 100 feet.

The locks are located at the east end of the dam in rock excavation. The usable length of each lock will be 1000 feet by 110 feet wide and 45 feet deep. There is a flight of three locks in pairs at Gatun, and the rise will be 85 feet above sea-level. There is one pair of locks at Pedro Miguel and a flight of two locks at Miraflores in pairs.

The culverts in the lock walls are 18 feet in diameter, and it is estimated that the time of filling the lock will be a little over eight minutes, or a rise of over 3 feet per minute. In ordinary operation the rate would be 2 feet per minute, or about fifteen minutes to fill the lock.

*Concrete Work for Gatun.*—The cement is brought from the United States, the rock from Porto Bello, and the sand from old Nombre de Dios, beyond. Sand for the concrete for the Pacific locks is from the peninsula of Chamè, west of Panama. Rock is from the west side of Ancon hill. Concrete lining for the Canal is only in a portion of Culebra cut, under water, and not, as many people suppose, the full length of the canal.

The gates for the locks are 7 feet thick, 65 feet long, and from 47 to 82 feet high. They weigh from 400 to 800 tons each. Eighty-four are required for the entire canal, the total weight being 58,000 tons. The locks are divided into 650 and 350 feet chambers, as 95 per cent. of vessels are less than 600 feet long. Thus, water can be saved in the dry season. At the end of the rainy season the lake will be at

rise in the Gatun Lake only 2 feet. Gatun Lake covers an area of 165 square miles. From Gatun to Pedro Miguel it is 32 miles. In the first 8 miles no digging is necessary; trees and underbrush only have been removed. At Bohio a few high points have been leveled off. For the first 15 miles from Gatun the channel is 1000 feet wide; from Tabernilla it is 800 feet for 4 miles, and thence to Bas Obispo it is 500 feet for 4 miles. Many million cubic yards excavated by the French between Tabernilla and Bas Obispo saved the Americans that much work, but that done by the French between the Atlantic Ocean and Tabernilla is not useful.

The Chágres River crosses the Canal not less than fifteen times between Tabernilla and Bas Obispo. At the latter town it turns abruptly northeast, and the Canal enters the 9-mile cut through the Cordilleras mountains known as the "Culebra Cut." For these 9 miles it is 300 feet wide to Pedro Miguel locks. Here, through one lock, Miraflores Lake is reached. This lake covers about two square miles, and is kept full from the Rio Grande and Cocoli Rivers, and also from water entering with vessels from the Pedro Miguel lock. From here it is eight miles to the Pacific entrance. It is estimated that most vessels can travel from deep water to deep water in twelve hours.

*Landslides.*—In order to give some idea of the vast landslides, the one at Cucaracha, just south of Gold Hill, is the best known, as it was a source of annoyance to the French in 1884. At that time it was 800 feet in length and covered 6 acres. It is now nearly 2 miles long and covers 30 acres. About 1,000,000 cubic yards are in motion. In 1907 it moved 14 feet in twenty-four hours, and overturned a steam shovel, while burying another. One hundred and fifteen thousand cubic yards moved into and across the cut with a glacier-like motion, completely filling it up for the time being. The French spent thousands of dollars for elaborate drainage systems, which proved inadequate. The only remedy is to remove the material. While important in themselves, these slides will not cost over one per cent. of the total amount of the digging. Tropical vegetation will undoubtedly cover the banks before the canal is completed, and thus hold them in place. However, the hill on which Culebra is built will cause considerable trouble in the near future by sliding into the cut. This will be worse than the Cucaracha slide, and time will show that this prediction is correct.

*Method of Excaavtion.*—The various excavation operations are

The material is loaded into cars, each car holding about 20 cubic yards. There are nineteen cars to a train, and it takes only about one hour to load the entire train. Each shovel loads from four to six trains per day. The material per train is from 500 to 600 tons. From Empire, the dirt trains move down-grade, south to Miraflores or Balboa (La Boca) dumps; from Empire, north down-grade to Gatun Dam and Panama Railroad relocation.

The Panama Railroad, although controlled by the United States Government, is a separate organization from the Canal. Of the total number of Government employees, 7700 are with this railroad. At Empire there are large repair shops for steam-shovels, employing 600 men. At Gorgona large shops, employing 1000 men, are used for locomotives, cars, and equipment other than steam-shovels. At these shops are iron and brass foundries.

The work requiring the largest number of laborers is in moving and ballasting tracks. In Culebra Cut alone there are about 75 miles of track, and in the whole central division 200 miles of track, exclusive of the double track of the Panama Railroad. Over a mile of track is moved per day in the Culebra Cut. In moving tracks on the dumps, a track shifter is used, which performs the work of 500 laborers.

*Costs.*—The average cost to the French amounted to about $4.00 per cubic yard, while the American costs vary in accordance with material and length of haul to dumping grounds, from 10 cents to $1.00 per cubic yard. The French received from the United States $40,000,000, which was ample from a conservative estimate, as follows:

| | |
|---|---|
| 29,908,000 cubic yards material removed | $27,500,000 |
| Panama Railroad, franchise, all rights, etc. | 7,000,000 |
| Drawings, maps, and technical data | 2,000,000 |
| Buildings and machinery | 3,500,000 |

About 43,000 acres of land went with the Panama Railroad property and 33,000 acres were acquired from the French Canal Company.

In consideration of the $10,000,000 paid to Panama for the rights conveyed, there was turned over to the United States, in addition, all public lands in the Canal Zone, amounting to 120,000 acres. This makes the United States Government the direct owner of 70 per cent. of the land in the Canal Zone, the remaining 30 per cent. being held by private citizens of Panama. The United States exercises governmental control over all.

The working hours are every week-day from 7 A. M. to 5 P. M., with two hours at noon for rest. There are no half holidays, only Sundays and legal holidays for rest.

The meals are the only item of cost in living. There are three meals furnished per day to the negro at 30 cents, to the Spaniard at 40 cents, and to the American at 90 cents. Having to pay only for meals, clothing, and laundry, it is possible to save as much in one year on the Zone as would take several years in the States.

Upon graduation from Syracuse University in 1884, Colonel Comfort became an instructor in mathematics and technical drawing in the Pennsylvania Military College (then the Pennsylvania Military Academy) at Chester. In 1889 he was advanced to the professorship of Architecture and made an instructor in civil engineering. In 1889 the college in which he was teaching conferred upon him the degree of Civil Engineer, and three years afterward he was made Professor of Engineering and Astronomy and appointed Captain and Adjutant of the college. Three years after that he was made Vice-President of the college and was commissioned a Lieutenant-Colonel by the State of Pennsylvania.

His career as a teacher in the Pennsylvania Military College covered twenty-six years. During this time he did much outside work in his profession, one of his most notable commissions being the designing of the steel work in the Yale University Library. He received, the day before his death, the appointment as Consulting Engineer of the City of Chester, his special duty being the supervision of the expenditure of the city loan, involving work estimated at over a million and a half dollars.

Colonel Comfort was a Mason, an Associate American Society of Civil Engineers, a member of the Penn Club of Chester and of the American Geographical Society. He served upon the school board of Chester and was president of the board of trustees of the Third Presbyterian Church of that city. He became a member of the Engineers' Club of Philadelphia in October, 1892, and was made a director, 1901 and 1904; vice-president, 1902-03; and president, 1905.

During his long career as a teacher and during his membership of the Engineers' Club, Colonel Comfort was held in high esteem and regard by all who knew him. At the Pennsylvania Military College he was popular among the students and remembered with respect by the graduates, which is the highest tribute a teacher may gain. His faithful attendance at board meetings of the Engineers' Club and the accuracy and care with which he edited the proceedings of this society during three years were matters of comment.

Colonel Comfort is survived by his widow, who was Helen de Lannoy, and two children, Martha, aged seventeen, and Frederick, aged fourteen years; also by a sister, Grace M. Comfort, of New York city, and a half-brother, Melville Lane Comfort, of Monroe, Michigan.

and the Secretary. The minutes of the regular meeting of May 19th and of the adjourned meetings of June 9th and July 14th were read and approved.

The following resignations were accepted as of July 1, 1910: Active Members, Joseph Upton, Paul W. England, and Gilbert S. Smith; Associate, Joseph Van d. Titus.

The Secretary announced the deaths of Washington Jones, George W. Hayes, and William D. Beatty.

The matter of the contract with the accountant, Charles W. Todd, was discussed, and the Secretary was authorized to extend this contract, if possible, for a period of three months.

The Committee on Increase of Membership, appointed October 25, 1909, was discharged with thanks, and it was ordered that a new Committee on Increase of Membership be appointed by the chair.

On recommendation of the Committee on House, the holding of a Smoker during the latter part of October was authorized.

The Committee on Revision of the By-Laws, appointed June 9th, presented its report, and following this, the Board recommended that the proposed amendments be brought before the Club for action.

# PROCEEDINGS

OF

# THE ENGINEERS' CLUB

OF

# PHILADELPHIA

## VOLUME XXVIII

EDITED BY THE PUBLICATION COMMITTEE

PHILADELPHIA
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1911

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PROCEEDINGS

OF

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PAPER No. 1093.

# THE BUILDING OF THE CITY.

HENRY LEFFMANN.
(Active Member.)

*Read November* 5, 1910.

THE figures of the United States census have shown for several decades a strong trend toward congestion of population in cities. It is true that the recent development of electric traction has slightly checked this movement, but it still remains a dominant influence. Space and time do not permit me to consider the several causes of this tendency, but it may be said, as a summary statement, that these are partly economic—that is, connected with industrial problems—and partly sentimental—that is, dependent on the gregarious disposition of mankind.

The origins of the human races are as yet unknown to us, but it is probable that some races are of very high antiquity, and that all were primarily of a very low order of mental and moral qualities. Some glimpses that ethnologic research has given us show man living in rude shelters, each family alone and at war with all others, subsisting by chase or on wild fruits, and being essentially in the same state as the most savage races today. Conditions slowly improved with some races, not appreciably with others. We are not able to determine the reasons for this difference. Probably the "aspects of

anticipate them; not to wait until they arise and then have to deal with them under conditions that are antiquated and insufficient. Items appearing frequently now-a-days in the newspapers and journals show that many are thinking along these lines. The present contribution will be probably more radical than any yet offered. Experiments have often been made in building villages, but usually either as pure land speculations, or as a sort of benevolent feudalism in connection with some industrial enterprise. Pullman, Gary, the several villages that the Krupp company has built, and some small enterprises in connection with factories in England are instances. These operations, well called by socialistic writers "toy villages," are too narrow in scope and too much involved in the industrial accessories to exemplify the principle presented in this paper. The founders of the toy villages play at building and management for awhile, then grow tired or die and *laisser faire* methods prevail.

The successful city will be planned from the beginning, not only as to its construction, but as to its operation. It will be run as a corporation for reasonable profit, for it will be found that the most satisfactory service can be given to the residents in that way, and hence a steady increase of population will result. The details of construction will be worked out by engineers, and the details of business methods by financiers before the construction begins.

To make the paper less abstract, some of the features of the proposed "Twentieth Century City" will be set forth. Let it be called Protopolis—"The Model City."

Commercial opportunities must be given prominent consideration. It is evident that the industrial situation in civilized countries has now reached such development that commerce is one of the mainstays of national prosperity. For commerce, the city must be located on the shore of a large river or bay, affording a deep channel and ample anchoring ground. A considerable area of flat land, a few feet above high water, should be available. This should be mainland, or at most separated from the mainland by a narrow, shallow channel, navigable only for small craft. It will be an advantage if, at a distance of about 25 or 30 miles, the level of the land rises rather sharply to a height of several hundred feet, but this is not essential. The body of water on which the city fronts should be so wide that no appreciable influence can be exercised by a settlement on the opposite side.

Protopolis will be laid out in "unit areas," each say 5000 feet

Each side is 25,000 feet long. To avoid complication in the drawing, only a few of the streets crossing at right angles are shown, but all the diagonal ones are indicated. The larger park areas are shown by the suppression of all the streets, except one diagonal, which is continued through each park, of course, as a sunken way, as is done in the case of the traffic streets in Central Park, N. Y. In the center of

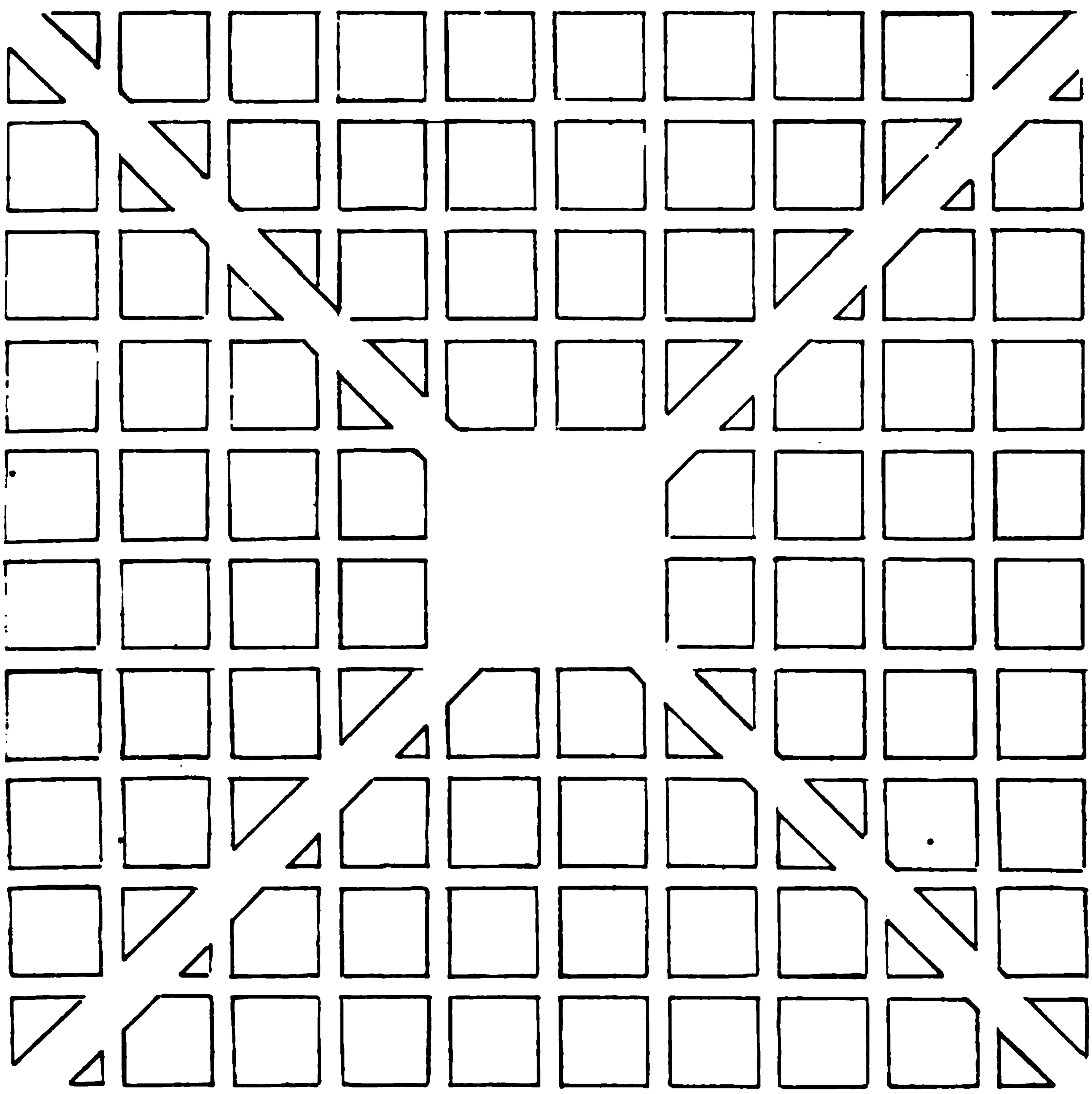


FIG. 2.

each unit area—the point at which two diagonals cross—four blocks are suppressed, making a local park area. All building blocks are 400 feet on each side. When occupied by ordinary residences, these blocks will be crossed in two directions, at right angles, by streets 50 feet wide not open to general traffic. These intersecting streets will also be employed in blocks devoted to business or manufacturing purposes, unless special reasons apply. For certain purposes the

building of a sanitary city. Mr. W. Copeland Furber made independently the same suggestion some years ago at a meeting of the Club. In the years since Dr. Richardson propounded his views great changes have been made in the methods of municipal administration, and many new problems, especially those connected with underground construction, have been developed. The application of concrete has simplified many features of construction, and there seems to be no serious reason against the adoption of the method. Consider what would be the comfort of a city in which no street excavation took place and almost no street repair. It is intended that street surfaces in Protopolis shall be similar to those used for the best footways. No asphalt, wood-blocks, vitrified brick or Belgian blocks will be

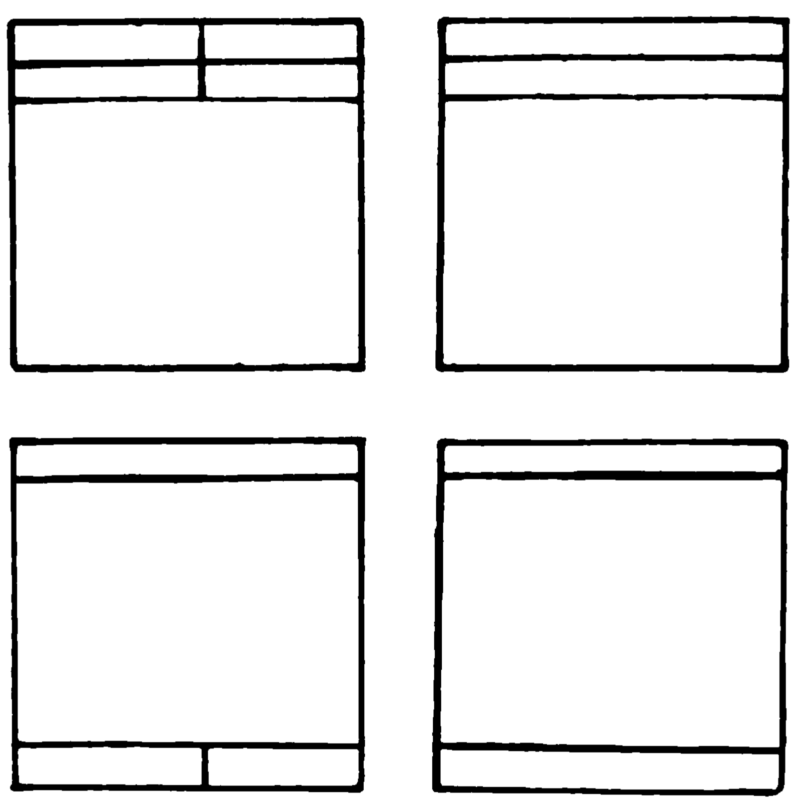


FIG. 4.

used, for no draft animal will appear on the streets. The horse is out of date for such purpose. All vehicles in Protopolis will be machine-driven—electric, internal combustion engine or any other source of power. The extensive area beneath the street, stretching from house line to house line, will afford room for all subway installation and for freight traffic. Of course, under the houses will be the usual cellar space. It follows, therefore, that no overhead construction will be allowed. There will be no necessity for surface tracks. The suburban connections will run underground or in a few places overhead. Communications at short distances will be carried out by automobiles. Interruptions of traffic will be far less frequent, as not only will many of the causes of such interruption be eliminated, but the vehicle can easily turn out of the way or seek another street.

high- and low-class residences, which is so marked a feature of Philadelphia would be avoided.

The engineering features of the model city could be discussed at much greater length, but time requires that something now be said as to the financing of the operation.

The financial management of American cities is a stench in the nostrils of decent people. Even the president of the United States, who is, or was until recently, an optimist, said a few years ago that if he was asked in what respect the development of the country had failed to realize the hopes of its founders he would place the failure to secure proper government of cities as one of the most disappointing events. Everywhere in American cities we see extravagance, neglect, stupidity. All of them are borrowing money for necessary improvements, yet there is no doubt that with proper management a modern city can be operated at a profit and yet give its citizens better accommodations than any American city gives.

A remedy for these troubles would be to make the entire city a business enterprise. The whole area should be owned by the corporation, under which the construction should take place. Such a corporation would, of course, require a large capitalization, but large sums are no longer startling. A capital of $100,000,000 is a trifle in modern finance, particularly when a fair return is assured. It is not possible to go into details, but it may be pointed out that an essential feature would be that no land should be sold. The corporation must retain control of every part of the territory, and thus secure the increment of value which the increase of population necessarily brings. Land may be leased for a limited term, subject to the most stringent building restrictions, so that the city plan may not be disturbed. In proportion as the necessity for street construction arises, the additional capital can be easily obtained. Residents of the city might be allotted a limited amount of the stock, but not enough to secure to them control of the corporation.

It is obvious that the success of this enterprise involves a not inconsiderable degree of altruism. This may be considered by many a serious objection, but there seems to be only two methods of solving the municipal problem. One is to transfer all ownership to the public at large, namely, socialism; the other is to establish a benevolent feudalism with an element of what has been called "enlightened self-interest."

However utopian and even fantastic these plans for the model city

A little more than a century ago, Philadelphia rejoiced in all the priceless blessings of individualism in its water-supply. Each family had its own well and pump, through which it received the seepage from its own and its neighbors' privies, and the city was repeatedly scourged by yellow fever.

To-day, socialism has deprived us of these blessings, destroying individual competition and individual liberty, even forbidding me to use my own pump, if I have one. The competition is now between city and city; and we see these communities reaching out, in competition, after coveted sources of supply; but this unseemly squabbling promises to work its own cure. In Massachusetts already the Metropolitan Water Board manages the water-supply, not of Boston alone, but of Boston and other towns; and New York's quarter-billion dollar Catskill aqueduct must surely be made to supply many of the populous towns along its line.

Thus all public utilities (and what utilities are not public?) are rapidly coming under the control of authority more and more nearly central; and the central authority is thus acquiring the knowledge which, one day, will locate all the various industries of our country, or of civilization, to the best advantage of all the people, and will intelligently plan our cities, if there be in those days anything corresponding to our present notion of a city.

Dr. Leffmann's remark that "A modern city can be operated at a profit" nearly repeats the recent expression of Mayor Reyburn: "Philadelphia gets as much, for the money she spends, as any great corporation in America." Why should she not? As a city, her million and a half of people, instead of wasting their energies in competition against each other, act as a unit, each applying a ridiculously small part of his income to the providing of municipal benefits for all. Every practical man must see that this spells wealth.

Dr. Leffmann is responsible for the statement that "the financial management of American cities is a stench in the nostrils of decent people"; but this stench tells us, more loudly than words, of the advantage derived from what we already enjoy of municipal socialism, without whose splendid economies, our cities could not stagger on, under their loads of graft, miscalled "political," and due solely to our persisting remnant of individualism.

B. A. Haldeman.—It seems to me, if the Club undertakes a series of discussions on the subject of city planning, such discussions should not be confined to the planning of a new, ideal city. Ideals change with the passing years; Philadelphia was an ideal city when it was planned by William Penn in the closing years of the seventeenth century, but it falls far short of the twentieth century ideal. Instead of dreaming of ideals let us turn our thoughts seriously to making such improvements to the city we already have as are necessary to keep it abreast of the progress of the age. Even though an ideal city could be planned and built as suggested by Dr. Leffmann, it would probably be impossible to induce the people of an existing city to remove to it.

The creation of a city is a process which extends through many generations, and each succeeding generation brings new conditions, new necessities, and new responsibilities which must be wisely provided for if the city is to thrive and prosper. This is the great lesson taught by Paris, which holds the proud distinction of being the world's most beautiful city only because she has been undergoing a constant and intelligently planned transformation during the past four

PAPER NO. 1094.

# MILITARY ENGINEERING.

CAPT. C. W. OTWELL (CORPS OF ENGINEERS, U. S. ARMY).

(Visitor.)

*Read October* 15, 1910.

MILITARY engineering sprang up with strife, and strife began when Adam made his transgression and received the curse of the Almighty, to earn his bread by the sweat of his brow. He was compelled to fortify himself against the cold by the growing of wool, against the pangs of hunger by tilling the soil, against the wild beasts of the field by the rearing of walls, and against the burning sun and the falling rain by the building of roofs. All this seemed natural enough, but when selfishness sprang up and brother sought the life of brother, minds were stirred to devise methods of defense. Cain built around his city, Enoch, on the Mount of Libau, a wall which was the beginning of fortification. The walls of Babylon, of Jerusalem, Tyre, Troy, and Carthage were but the development of this idea of the necessity of protection. A study of history will show that that nation ruled which made the best use of engineering devices, not only for defense but also for aggression.

With the lapse of time has come progress in the art of attack, and this has, of course, brought forth stronger and stronger types of walls. Each advance in method of attack has been met by a counter-invention for defense, so that the defense always has an advantage over the attack. The attack is sure to succeed only because it is prosecuted regardless of cost. Stones, spears, swords, ballista, catapults, smooth-bore guns, rifles, and explosive shell have each in turn caused the invention of appropriate methods of resistance.

For centuries the walls had the decided advantage, but the catapult, invented by the Syrians, ballista, invented by the Phœnicians, and the battering ram, seemed to mark the limit of progress in the weapons for attack until 1320 A. D., when a monk, Bartholdus Schwartz, discovered the formula for gunpowder. The arrows and large stones of the attackers and the hot pitch of the defenders had to be discarded and new implements devised. The tall towers on the walls which

and many engaged in civil pursuits. The Baltimore and Ohio Railroad was located and largely constructed by engineer officers. The now Northern Central, Erie, and Boston and Albany, were the projects of McNeil and Whistler; the latter having been later chosen by the Russians to build their first railroad from Moscow to St. Petersburg. Alexander Dallas Bache, a graduate of 1825, reorganized the Coast and Geodetic Survey. Benjamin H. Wright built the first railroad in Cuba and Talcott the first one in Mexico. Eugene Griffin, formerly general manager of the General Electric Company, may be called the father of the electric street railway, for it was his report, comprehensive and scientific, from an economic as well as a strictly engineering standpoint, which was the beginning of the movement for that class of frequent, cheap, accessible and quick transportation which is to-day one of our greatest national blessings.

The essential quality demanded of a military engineer is familiarity with certain principles. He is more apt to find himself in a place practically destitute of resources than in one where every facility is at hand. The United States Military Academy training is based on this theory. It would be a manifest impossibility to educate in all the specialties liable to be encountered in practice. The problem of the military engineer is ordinarily not like that of the civil engineer—carefully choosing materials and plant in order to do the work in the most economical method; but rather of doing his task with whatever material, labor, and tools may happen to be available. Often railroad iron must take the place of beams; cornstalks, poles, and straw the place of boards; wooden pins the place of nails; vines the place of rope, and an apparent nothing the place of a very large something badly needed. To carry the material and plant necessary to prosecute most economically any and every kind of work likely to be encountered would require an impossible amount of transportation.

The English word "engineer" is a comparatively modern term, and was first applied in the military sense only; Captain John Rudd, in 1650, being known as "Chief Engineer." The word succeeded the words "trench-master" and "camp-master." The general understanding of the term was "an officer skilled in the art of attack and defense of fortified places." The art of fortification involved so many other arts that the engineer was necessarily compelled to familiarize himself with many branches of what is now called "civil engineering." Water-supply, roads, disposal of waste, mining, and various works of construction were essential in order to make the

more important fortifications; he has general charge of the engineering features of siege operations, the construction and maintenance of military roads, bridges, piers and wharves, and the construction, maintenance, and operation of railroads under military control; he supervises the demolitions ordered by the commander, and the laying out and preparation of permanent camps. To carry out his duties he should have the necessary military assistants, ample funds, and authority to employ civilian labor, etc. Requisitions for funds, disbursements, and the care and disposal of property pertaining to the work in charge of engineer officers is subject to the regulations prescribed for the government of the Engineer Department."

The regulations give instructions as to map-making and scales and as to the diaries to be kept by organizations. Under the heading "Service for the security of the army" it is stated that "engineer troops are detailed when required," and "engineers are usually attached to an advance guard to remove obstacles, repair roads, etc." "Circumstances may also require a bridge train to be attached." The description of the typical formation of an advance guard for an independent division includes one company of engineers. The mounted detachment of the engineers is placed with the support of the advance guard, and the dismounted portion of the company with the reserve of the advance guard.

On the subject of the rear guard it is stated that "engineers are generally necessary to render the roads and bridges impassable and to throw obstacles in the way of the pursuing force of the enemy." It further states that "demolitions and obstructions are prepared by the engineers, assisted, if necessary, by other troops detailed from the reserve, and completed by the mounted engineers of the rear party at the last moment. Instructions of the supreme commander govern in the demolition of important structures." "Engineers are usually attached to the outpost to assist in constructing intrenchments, clearing the field of fire, and opening communications laterally and to the rear." "During the preparatory stage (for combat) the engineers open roads to facilitate lateral communication and to enable the artillery to move rapidly to the front when an advance of that arm becomes desirable." "Night attacks are made mainly by the infantry. Engineers are added when obstacles are to be removed or surmounted." On the defensive it is stated: "If possible, a reconnaissance should be made by the commander in person, accompanied by officers of the general staff, artillery and engineers." In

senting the lay of the ground. While few records remained after the destruction of Carthage, history records that Hannibal always completed his reconnaissance in person. The beginning of the development of the art of map-making as applied to military operations was during the French Revolution. It was the maps which Carnot, himself a graduate military engineer, had had prepared by the topographic engineers, organized as a result of experience gained in the revolution, which enabled him to send out and keep in the field fourteen armies in as many directions. His strategy, however, was as poor as his mapping was good.

There is considerable difference between civil and military practice, both as to maps themselves and as to the manner of their making; the nearest resemblance to the military maps being those used in railroad location. Generally speaking, the civil survey shows relative locations; the military map must go more into detail. An army must know where it can find forage, fuel, water, and food for its existence. To coördinate an advance it is necessary to know the length of time required to pass over the various distances, which condition demands that there be known the rivers and their crossings, the location and character of the roads as to both grade and nature of the roadbed. In marching to the attack, it is necessary to know how the advance can be made out of sight of the enemy and protected from his bullets. These requirements demand that the hills, woods, and growing crops be shown.

Upon consideration it is also apparent that the character of the reconnaissance will vary with the particular state of the advance. While the nature of the duties required of the mounted engineers will depend on the nature of the country, it is probable that they will have sent in sketches of the roads in the front. While these may not be contoured, they will have all the roads, and these road sketches, together with the civil maps ordinarily obtainable, will form the basis for assigning the work of the more detailed reconnaissance. It is important that the work be well apportioned, not only according to the difficulty of the ground, but also with due consideration as to the abilities of the sketchers. The sketches must all be turned in at practically the same time. The director proceeds along the road, or other line which he takes for his control line, and posts at each crossroad suitably marked cards giving the elevation and indicating the number of the sketcher designated to cover the outbranching roads.

the string, with any small weight tied to it, will serve for a slope board. The direction is carried by back-sighting, using the pencil as an alidade. The construction of the scale of distances and of map distances requires that the sketcher know the length of his stride and a certain distance, as one inch, on the paper. He should also know the various map distances of the contours, although this is not absolutely required, for he can construct the scale graphically by remembering that a radian is 57.3 degrees. It would seem that the results to be obtained with the simple instruments mentioned would not be of value, but it has been found that with training very close work is possible, the average man sketching about two miles per hour.

The method already described covers only the field of road sketching done on the advance. When the point is reached where it is presumed that the enemy will give battle, it then becomes necessary to make what is known as a position sketch. This requires more detailed information, and the scale is therefore increased to 6 inches equal one mile and the contour interval decreased to 10 feet. The control line is determined on, generally parallel to the front, and the director divides the front to be covered into areas about half a mile wide and two miles deep; that is, perpendicular to the front. To each of these areas is assigned a party of one chief sketcher and two assistant sketchers. The director marks, by stakes set along the control line, the points of divisions between the areas. Each stake has written on it the elevation of the point. The chief sketcher of each party sends his two assistants to the bounding stakes, one on each side of his area ,who there meet the corresponding members of the neighboring parties. The two sketchers, one from each of the bordering areas, make a sketch (one only) of the area along the boundary-line, taking in a strip about 300 yards wide in each area. The chief having sketched in the portion along the control line proceeds to the end toward which his sketchers are working and gets them together at that end. They having arrived at the end of their strips, actually cut the sketch, which it will be remembered contains a strip from each area, along the boundary, and each sketcher takes to his chief his portion of the sketch. The latter orients and places his own and his assistants' sketches in proper relative position and pastes them together. This leaves a strip about 200 yards wide down the center of the area which is not yet filled in, which is sketched in on returning to the control line. When all the sketches are collected, they are sure to go together, for the reason that they were, along the boun-

have time to man the parapet after the artillery ceases firing and before the infantry reaches the obstacles; this, coupled with the consideration that the obstacles must be far enough away to prevent the throwing of hand grenades into the trenches before the enemy gets to the obstacle, determines the distance to be about 150 yards in front of the trenches.

The best form of obstacle against infantry is believed to be the high wire entanglement. The Russians used trous de loup, or military pits, extensively. The Filipinos used much the same type along the roads or paths. They dug pits, covered them with light bamboo strips and straw, and these with earth, and then placed sharpened stakes in the bottom and sides, sometimes poisoning the tips also. The troops finally insured the discontinuance of the practice by impressing native guides, captured in the neighborhoods, who were compelled to lead the columns.

Abattis is an obstacle formed by placing felled trees close together in a row along the front, branches pointed and toward the enemy. It can be destroyed by fire of artillery, and for this reason it is customary to protect it by a very low parapet. Slashings differ from abattis in that in this form of an obstacle the trees are left in position where felled. This forms an obstruction, but not necessarily a continuous one, unless the trees are very close together. It is of particular efficacy in obstructing roads through forests. It was the slashings made by McClellan to protect his right flank which delayed Stonewall Jackson from striking Porter at the beginning of the Seven Days' Battle. A simple engineering work thus saved the Federal army from almost certain defeat.

There are several forms of obstacles used against cavalry. Chevaux de frise and low wire entanglement are employed principally. In the latter the stakes to which the wire is fastened are only some 18 inches above the ground. The chevaux de frise consist of a line of crossed stakes or iron rods sharpened at the ends, either passed through a beam or otherwise fastened at the point of crossing. In side elevation it resembles a saw-buck. Several modifications of this idea were used by the Russian and the Japanese as a portable obstacle against cavalry. One feature of the Russo-Japanese War was the paucity of cavalry operations; however, an attack of cavalry, mounted, against infantry intrenched, where such obstacles would be used, is believed to be past history.

The establishing of communications between the various portions

elevation. The siege of Syracuse under Marcellus, in 212 B. C., was withstood for eight months, and would probably have continued indefinitely by the clever devices of Archimedes, had not the Sicilians fallen victims to enticement. The sieges of ancient days meant much to the defenders, for it was death or slavery to the losers. However, they did not, as to-day, mean a vigorous prosecution of attack, but were more of the character of a blockade. The siege of Troy in the twelfth century B. C. was of eight years' duration; the siege of Ithome in Messinia, by the Spartans in the eighth century B. C., was likewise a drawn-out affair—eight years. The siege of Ira, in the succeeding century, took up eleven years.

A great advance was made by the Greeks in the fifth century, when they formed their lines of circumvallation, prepared covered ways and approaches toward the walls, and invented the process of mining under the walls. At this time explosive was unknown, but their methods were the same practically; they would run a shaft under the walls, make a mine chamber, and build hot fires in them. The heat would cause the earth to crumble, and finally cause a breach in the wall, toward which the assault could be made. There was a great improvement in the art of fortification and siege methods during the French Revolution; by this date the captured garrison were considered prisoners of war, which feature tended to lessen the efforts, formerly so imperative, to endure the siege.

The modern method of conducting a siege is to establish the line of investment, place the artillery in position, usually about 3000 yards from the defenders' lines, and then, the points of attack having been determined upon, open the first trench, generally parallel to the defenders' line of works. This trench is called the first parallel; it is usually about 1200 yards from the enemy. Zigzag lines, called approaches, are then run toward the front, being given directions such that they lie outside of the tangent to the enemy's most advanced works which bear upon the approaches, the excavated earth being thrown on the side toward the enemy only; this is called a single sap. When the approaches have been pushed so far to the front as to be beyond the limit of effective protection by troops posted in the first parallel, it is necessary to open another parallel; this will be about 600 yards in front of the first parallel. This parallel completed, approaches are again started to the front. At this stage the fire of the enemy may be so plunging as to require protection on both sides and in front, when what is known as the double sap is started; this is

easy to appreciate that there is an intimate connection between that work and the improvement of the harbors which they protect. It could not be said that it is absolutely necessary, in order to draw plans for the defense of a port, that the improvement of its harbor be executed by the same engineer. However, for several reasons, it is certainly more convenient that it should be so.

First, any alteration of the roadstead or of the channel, which might be taken advantage of by an enemy, is no sooner planned by the engineer in charge than the necessary steps are taken for the defense.

Second, since this country will never establish permanent fortifications for the defense of our seaports from the land side, and, in consequence, all that will exist in the way of preparation for defense will be the plans of the provisional fortifications, the advantage of having an engineer officer, usually of considerable experience, in charge of operations in the vicinity of the seaports, so as to familiarize himself with the local resources, topography, labor supply, and conditions in general, and thus be prepared in time of war to commence the vigorous prosecution of the defenses, can well be understood to be a great asset. Practically every city on the seaboard, which has any value as a port, has a district engineer office or a branch of such an office. The plans for the defense of the locality are familiar to the officer in charge, and he usually has a sufficiently large working force under him to organize the necessary parties for constructing the works upon the outbreak of hostilities.

The third, and probably the greatest reason for putting the river and harbor work in charge of the army engineers is that they must have something to do to keep them from rusting out in time of peace. It is believed, from what has been said above, that it can be appreciated that the exercise of engineering ability in time of war requires that the officer be practised in his art and that he be thoroughly alive; that he must have back of him achievements to give him that confidence which nothing but past successes in dealing with men and with engineering problems can give him. The art of fortification and the other varied duties which, judging from the past, are sure to come to the engineer officer in time of war involve many branches of engineering, such as water-supply, waste disposal, road and bridge construction, power transmission, mining, and various branches of municipal engineering. During the late war with Spain it was necessary to build a steel bridge, reconstruct many other bridges, restore and

probably the principal reason, as stated by one of the leading engineering periodicals, is that the Corps of Engineers is a strictly non-partisan body, entirely free from local prejudices, composed of men who are fearless, owing to the security of their position, and who therefore ought to be able to render an unbiased opinion. While this opinion may not be very satisfying to the congressman himself, he knows his colleagues will be accorded the same treatment.

There are to-day many branches of civil engineering in the government service, and it would appear to be only ordinary business sagacity for the government to retain one branch of the national public works for its protégés. The river and harbor work is but a small part of the total engineering done by the government. There are many openings for engineers in the various branches of the government service, among which may be mentioned the Reclamation Service, the Geological Survey, the Coast and Geodetic Survey, public building construction under the Treasury Department, and others under the Agricultural Department.

The civil engineer does not need to enter the government employ to render the country more than his share of service, for to-day it is he who is coming to the front as the logical director of public affairs. In the practice of his private business he is making the earth produce results from her latent resources. The cry of late has been, "Give us a business man for mayor, or for governor"; the author would amend this by saying, "Give us an engineer for our mayor or our governor." In fact, the governing of our cities especially, and of our states very largely, consists of the solution of civil engineering problems. As the people consider the proposition more and more, it will be found that they will insist on having men as public officials who know how to execute public improvements economically, and who will do it honestly.

In time of peace the engineer is a public benefactor; in time of war he is his country's reliance. The successful handlers of men in time of peace will be found leaders of men in time of war. There is every reason for coöperation between the engineer in civil life and the military engineer; the country needs the engineer in time of war, for modern war is getting to be more and more an engineering proposition. Knowledge of what materials, forces, and men can do, and practical experience in using them, are what win the day. The engineer is the man who, more than any other, should be well qualified.

if a good grade of coal is exposed to a heavy rain, it gets quite wet, and is more difficult to burn without smoke, owing to the fact that it packs when put on the fire, shuts out the air, and cools down the fuel bed at that point. If a coal cakes and is charged into the furnace in large quantities it may form a compact mass and shut out the air. In barring up the fire, there is a good deal more smoke produced than when it is charged into the furnace, which can be obviated by shoveling in smaller quantities. It will be necessary to disturb the fuel bed only when ash or clinker has accumulated to such an extent as to prevent the air from passing through all parts of the fuel bed.

If large sizes of coal are used, the air is usually admitted quite uniformly through the fuel bed. If there is too much air, the efficiency obtained is not as high as when the smaller coals are used, but the larger coals give less smoke.

The quantity of fuel that has to be burned in different furnaces is a great item. With a given size combustion chamber one can usually burn a limited quantity of fuel without smoke, but if its capacity is exceeded, the tendency is to smoke more and more, as, for example, a locomotive, when it is crowded to four or five times the capacity of ordinary boilers. Under such circumstances one cannot expect to burn all the volatile gases, and they will appear at the top of the stack as smoke.

In burning coke or anthracite coal, the fuel is nearly all consumed on the grate or above the grate; but where bituminous coal is burned, it requires some time for the liberated gas and air to mix and ignite. A larger combustion chamber is required for a higher volatile coal. In other words, there are two kinds of fuel: coke on the grate, and a gas which burns above the fire in the combustion chamber. If the combustion is not completed in the chamber, there is a loss of gases, and particles of carbon are deposited on the boiler-tubes. This carbon usually comes from the breaking-down of the heavy hydrocarbons.

The draft is another important item in preventing smoke. Many plants have not draft enough to burn coal at the higher rates. Firemen who have to do everything possible to get air through the fires, will produce smoke when the capacity of the furnace is crowded. Every plant should have more draft than is necessary to burn the coal under ordinary conditions, and then that draft should be made effective only when the load is very heavy.

The character of the load is important, because, if a steady condi-

the boiler-tubes. This sometimes causes a loss of unburned gases as high as 5 or 6 per cent. of the value of the coal—a result often of poor firing.

Then there are the furnaces with the water surfaces of the boiler forming the top of the combustion chamber, and side walls of brick, something like the Heine boiler. These boilers have a longer passage for the gases, which do not go directly up from the fire, but flow in a horizontal direction, and after passing over the bridge wall and over other obstructions in the furnace, mix, and then have a space of about 10 feet to burn in. In boilers of this type it is easier to prevent smoke than where the gas enters directly above the grates.

Furnaces of the last type are modified by brick arches, piers, etc., to assist in mixing the gases. There may be a set of piers which cause the gases to travel back and forth, and many such furnaces are burning bituminous coal, with good results.

Another common method of preventing smoke is by the use of the steam jet. The use of steam jets is not economical, but it will stop smoke. Steam jets are applied to nearly all of the classes of furnaces just mentioned.

The automatic stoker is usually considered the best method of abating smoke, and it can be applied to boilers of almost any type. The stokers work best where there is a large combustion chamber for the gases to burn in before reaching the boiler surface. The mere addition of two or three feet to the combustion chamber of a boiler has oftentimes changed a smoky plant to a practically smokeless one. In the west a certain type of chain grate stoker would oftentimes make some plants entirely smokeless, and other plants not. In the latter cases the difficulty was accounted for by not having a long enough space for the gases to burn in, and by moving the stoker out two or three feet a combustion chamber was provided, necessary for the ready and smokeless combustion of the coal.

Some automatic stokers are so well designed with respect to the setting for a particular boiler that it is very difficult to make it smoke.

The statements may be summarized as follows:

Any type of boiler may be operated with but little smoke with low volatile coals, and in some cases with other coals, provided the rate of combustion is very low.

Hand-fired furnaces with brick arches are more easily operated without smoke than the plain furnaces.

information pertaining to and bearing on the smoke question. Such an organization advises owners of plants regarding changes either in the equipment or the methods of firing which will reduce the quantity of smoke. The most important thing is to have supervision of all new boiler plants that are put in and of the remodeling of all old ones, so that it will be done along the lines of smokeless furnaces. One of the most hopeful things is to find in some of the cities that nearly all the new plants—especially the large plants—are being installed, in the best way known at the present time to prevent smoke, and in nearly all of the larger cities it will be found that the most recent plants are pretty successful in the abatement of smoke; and as it is only a matter of time when the old plants will be remodeled, or rebuilt entirely, they too can be brought into that class. The discussion of the smoke problem for a city like Philadelphia should, in part, lie along the line of the best methods of organizing a smoke commission. It does not pay, in trying to stop smoke, to antagonize manufacturing interests, and it is not necessary to do it. Manufacturers and other business men are usually interested in the welfare of the city, and they will take steps to do things, if brought before them in the proper way. Occasionally one may find men who will not, but such are exceptions.

Two cities are working along lines suggested. One, Cleveland, Ohio, has perhaps been working on such lines for the longest time. It is not a smokeless city, but it has a number of plants that are quite smokeless, and they are being added to all the time. At the time the smoke abatement idea was about to be put into practice, Professor Benjamin, of the Case School of Applied Science, was prevailed upon to take the position of smoke inspector in Cleveland. He is an engineer who has given a great deal of attention to smokeless combustion, and he started out with the idea of getting as many new plants as possible into line, and whenever a man changed an old plant, he would have him change it along the right lines. There is very little friction in Cleveland between the city officials and the business interests, and many of the large manufacturing interests are putting in plants that are automatic.

The city of Chicago has had a serious time with smoke problems. Many of the coals there are high in volatile matter. A good many things have been tried; three or four serious trials at preventing smoke have been made in the last twenty years, and not one was successful until the last one. Finally the entire thing was taken

on the ground that such nuisance is prejudicial to public health. This position could not be successfully maintained in court, however, as smoke does not cause consumption, influenza, or, in fact, any particular disease.

As evidence of this the vital statistics of the United States and Europe in towns where the smoke nuisance is most marked do not show an increased mortality from pulmonary diseases. In Washington, New York, and Los Angeles—so-called clean cities—we find per 100,000 of population a higher mortality from consumption than in moderately dirty cities, such as Philadelphia, Buffalo, Detroit, Milwaukee, and Boston.

In the latter city, according to the United States Census Report for 1908, the mortality from consumption was 146 cases per 100,000, while in such cities as Pittsburg, Cincinnati, Chicago, and Youngstown, where the smoke nuisance is more marked, the mortality was 149 per 100,000, or only three higher than moderately dirty Boston.

Smoke does have a decidedly irritating influence, however, especially on the mucous membranes of the upper air-passages. It reduces the vitality of the individual, thus making him more susceptible to disease. It undoubtedly cultivates a more fertile soil for the development of pathogenic germs than would be found on normal mucous membranes. It also has a deleterious effect by reason of aggravating the condition of those parts already diseased.

During my first year as Director of the Department of Health and Charities I was optimistic, and undertook a solution of the problem from a health standpoint. To ascertain if I would have the backing of the medical profession in a crusade against the smoke evil, I communicated with a hundred of the more prominent physicians of the city. The majority of these, particularly the specialists on the eye, ear, nose, throat, and lungs, felt that the position of the department could be maintained from a health standpoint. A minority believed the smoke could be construed as a detriment to public health. The large majority, however, felt that notwithstanding the injurious effect of smoke on delicate mucous membranes, the department's health position could not be maintained in court. Again, a small minority, among whom were several of the most prominent sanitarians in Philadelphia, declared that the evil must be handled as a "common nuisance," and not as a "health nuisance." Among the correspondents were several, one a tuberculosis expert of international

and I recall having received a pamphlet from that place setting forth the great improvement there in smoke conditions brought about by legislation and the appointment of smoke inspectors. This pamphlet contained beautiful photographs presenting conditions after the improvements; and also photographs of before. During a recent visit to Milwaukee I was somewhat surprised to find conditions there much worse than in Philadelphia, and I believe we are better off without legislation than Milwaukee is with it.

While I have urged more efficient legislation, I would be glad to have a movement started from the engineer's standpoint along educational lines, demonstrating the proper handling of the fire in all its essentials—location of the grate, air-space between the grate and boiler, improved automatic stoking, etc. By these means it could be brought to the attention of the doubters and the unbelievers that eradication of the smoke evil is not only a public necessity and blessing, but that it is practical economy to large coal consumers and means the saving of dollars. I know of no better organization for the launching of this important public duty than the Engineers' Club of Philadelphia. Should this club decide upon such a course, it will certainly have every assistance and co-operation from the municipal Department of Health and Charities, and the heartfelt thanks of the health officials and the community at large.

James Christie.—The smoke nuisance is a never-ending problem with all cities whose principal fuel is bituminous coal. While the emission of great volumes of dense black smoke can be and is controlled and abated, yet it is never entirely prevented. Of the British cities, where every means of repression has been urged during the past century, all that can be said is that the nuisance is not so great as it would have been if the methods pursued for its repression had not been exercised. And yet it is a well-known fact that bituminous coal can be and is, under certain conditions, burned without the emission of smoke. The volatile elements which produce the smoke and soot are the first to be liberated by heat, and this distillation occurs at a much lower temperature than that of ignition; in fact, the distilling process is a heat-absorbing or temperature-lowering process in itself. Furthermore, the particles of carbon which form smoke ignite and burn reluctantly, and at a high temperature only, as can be observed with soot or lampblack—an amorphous form of carbon formed by the condensation of smoke. A result of these peculiarities is that when smoke is liberated above the fire under

emission of smoke from the furnaces of steam boilers. But this condition may not last. Anthracite coal advances in price, while the general tendency is for bituminous coal to go lower in price on the Atlantic coast. Even now the housekeeper could effect some economy by changing to bituminous coal. The time is probably not far distant when the change will become irresistible.

An English writer, discussing the smoke problem some forty years ago, could see no solution except by the adoption of gaseous fuel in cities. Since that time a new solution has appeared on the horizon through the introduction of the by-product coke oven. The innumerable products of gas-tar recovered by this oven are of such value, and in such great demand, that the coke product may become of secondary value, and in proportion to the thermal values the coke product may be offered at a lower price than the raw coal which produced it. In this way can be obtained a valuable and a smokeless fuel.

But coke, and especially that derived from the by-product oven, has decided limitations for most purposes. It is friable, light, and bulky, and not well adapted for rough handling or transportation. Here much can be learned from the Germans, who treat their inferior coals and lignites by briquetting, and convert them into an admirable fuel. Coke with an admixture of the raw coal, and a modicum of tar as a binder, can probably be briquetted into a smokeless fuel, suitable for any purpose, and produced at a price, that would drive the raw coal out of use. If this can be accomplished, the smoke problem will be solved in a simple and economical way. And not only the smoke problem, but possibly also the dust problem; and city dust, from a sanitary point of view, is more objectionable than smoke. Treatments of city roads by solutions of tar are the most effective means known for preventing a dusty atmosphere, and it is evident that a vast quantity of tar would be available if that wasted in the old type of coke oven was preserved.

E. M. Nichols.—About twenty years ago I was associated with a commission interested in the prevention of smoke. We made a test of two stokers in a battery of ten boilers. The same conditions prevailed at the time of this test; we had two stokers and two chimneys, and we made a test of coal from the same mine. In one set of boilers we used screened lump coal, and in the other slack pea coal. The slack was put in by the stoker and the lump coal was hand-fired by an expert fireman who was especially instructed to make

smoke-laden are so serious that it is of the utmost importance that such meetings as this should be more widely held, until the public demand and right for a clean air will have been met. The waste in coal unconsumed is trifling compared to the ultimate sacrifice of health and lives directly and indirectly because of the smoke evil.

Air vitiated by smoke contains not only the fine particles of tarry carbon, but more or less offensive, irritating, and inflaming carbonic and sulphurous gases. This is a matter of ordinary every-day experience and distress to those who ride in steam railway trains, or who live near our railways and railway stations.

Is it any wonder that respiratory diseases and diseases of the mucous membranes are so common and habitual in our big cities, where railways and factories daily pour forth such tremendous volumes of black smoke? Sore eyes and eyelids, catarrh of the nose, throat, and bronchial passages, may be produced directly by the mechanical irritation of smoke particles; and, when these conditions are the result of other excitants, smoke seriously aggravates the illness and tends to promote an incurable chronicity of the case. It is held by Aufrecht and others, the opinion being based on the study of certain cases, that bronchopneumonia is not infrequently induced by smoke irritation.

In these days of the popular and much-needed crusade against tuberculosis a special word needs to be said. Smoke does *not* produce this disease. The infective agent, the bacillus of tuberculosis, is carried in dust—*pulverized poison,* I call it—contaminated by dried sputum of consumptives. However, the smoke evil, if not a direct producer, is indirectly an important and serious predisposer to the disease. This happens in two ways: first, by local irritation of the membrane of the air-passages it sets up a catarrhal susceptibility to infection; secondly, by the habitual catarrhs and insufficient quantity of fresh air so contaminated by smoke the general systemic resistance to disease is diminished, and when the recuperative and reparative powers of the body are thus debilitated and weakened, the bacillus soon finds favorable soil and lodgment, and ready access to the vulnerable tissues.

It is well known, as has been pointed out by some of our noted physicists, such as Prof. Carl Barus, of Brown University, that our heaviest fogs and most heavily-laden humidities are caused by the presence of a nucleus of carbon or smoke, or of dust, surrounded by an envelope of moisture. That is the reason that London has so

prevail. The smoke nuisance is one of these, and it should be put down. It subtly, but nevertheless truly, nags and affects the health and physical stability of thousands of our women, and our men too; and therefore anything that the Engineers' Club can do to abate the smoke evil will contribute tremendously to the public health, and to the improvement and progress of the race toward bigger influence, activity, and usefulness.

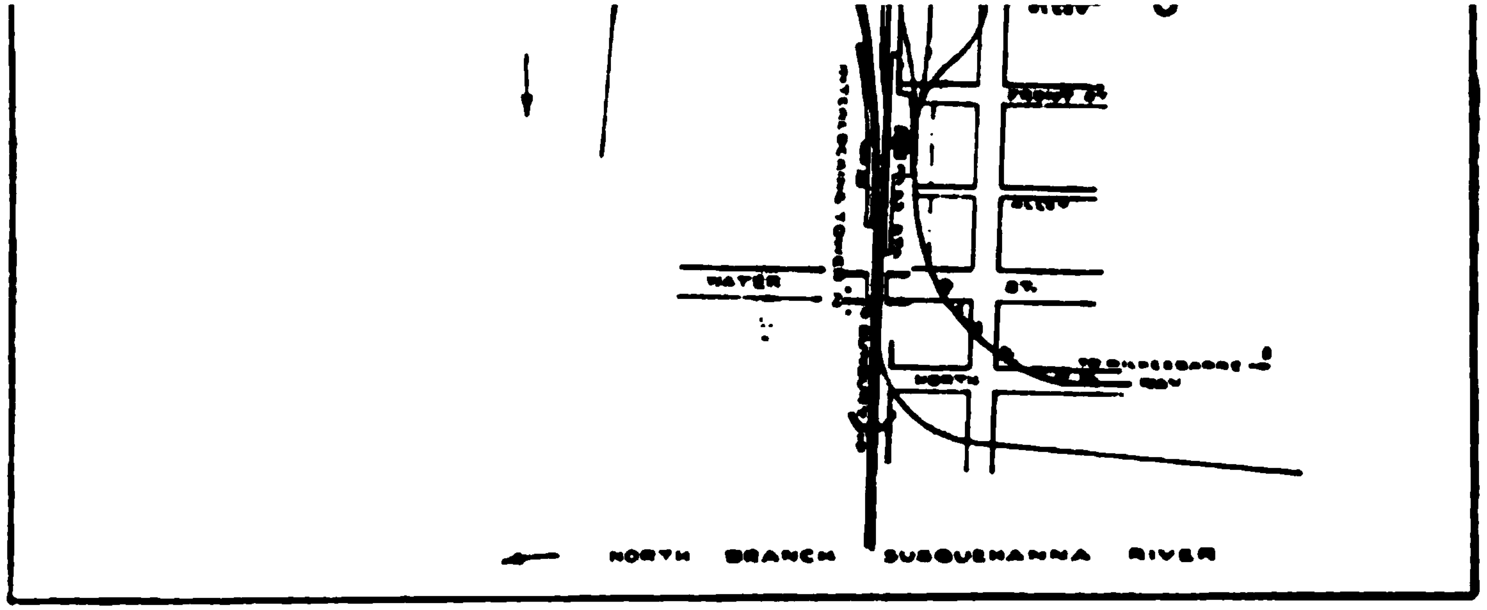
John M. Lukens (Visitor).—Within the last four years there have been 279 smoke-consuming appliances installed in this city. The total number of boilers in actual use in Philadelphia is 7103, of which 4752 use hard coal and 2209 use soft coal; the remainder use other kinds of fuel.

In regard to the Pennsylvania Railroad locomotive yards in West Philadelphia, the railroad company has placed two of its best men in that yard in order to instruct the firemen and engineers in the proper handling and management of the coals used. They have reduced the smoke nuisance considerably, but have not been able up to the present time to prevent it entirely.

Action has been brought against fifty-six concerns for violation of the smoke ordinance, and penalties have been enforced against twenty-five of them. One hundred and seventy-seven firms changed from soft to hard coal during the last four years. At the present time there are only about two places on Market Street, between the Schuylkill and Delaware Rivers, using soft coal—the Bingham House and Blum Brothers.

The number of smoke inspections made from 1905 to 1909 was 8985, and much work is being done in Philadelphia toward smoke prevention.

Henry Leffmann.—I can add little, if anything, to this discussion, as the points have all been covered. The question may be simply stated thus: Can soft coal be burned with reasonable economy without appreciable smoke? If so, has not the community at large a right to insist on such a method even though it involves some expense to the user? It has been well said that, after all, the largest business in a city is housekeeping, and the housekeeper has rights which the municipal authorities ought to maintain. It is said that we must not interfere with manufactures, but we do so interfere in many ways in the interest of public comfort and public health, and why not in regard to unnecessary smoke?


WATER
ST.
NORTH
NORTH BRANCH SUSQUEHANNA RIVER

# IN MEMORIAM.*

## WASHINGTON JONES.

Our venerable fellow-member passed away on the 30th of last July in the eighty-ninth year of his age, retaining his usual activity until within a few days of his demise.

Mr. Jones was born in Philadelphia on February 22, 1822, and became an apprentice at the works of Merrick & Agnew, at the early age of fifteen years; it is said being the first apprentice taken in that establishment. His industry and capacity were attested by his advance to positions of responsibility there and in several other engineering works of this city, such as the Southwark Foundry, Merrick & Towne, and the Penn Treaty Works of the Neafie & Levy Ship and Engine Building Co. He was associated with the Port Richmond Iron Works of the I. P. Morris Company, as Constructing Engineer, from 1856 to 1891, with a brief interruption of a few years at the Southwark Foundry, and bore an important part in the productions of that establishment during the Civil War.

Mr. Jones became a member of The Engineers' Club in May, 1882, and served as President in 1886, and was elected an Honorary Member in 1908. He was a member of the American Society of Civil Engineers; Member and Vice-President of the American Society of Mechanical Engineers, and was the oldest surviving member of the Franklin Institute, having been a member continuously since 1847, and was a Vice-President of the Institute at the time of his death.

* Prepared by James Christie and Henry J. Hartley.

committee to prepare a memorial of Washington Jones, should be given as Henry J. Hartley.

The several amendments to the By-Laws proposed by the Board of Directors at the meeting on September 17th were brought up for discussion, and, on account of the time required, it was ordered that the discussion of the amendments be continued at an adjourned business meeting, to be held November 5th, prior to the regular meeting of the Club.

Captain Curtis W. Otwell, visitor, presented the paper of the evening, entitled "Military Engineering," and, following its presentation, upon motion of Captain Cooke, the thanks of the Club were tendered to Captain Otwell.

Adjourned Business Meeting, November 5, 1910.—The meeting was called to order by President Easby at 8.25 p. m., with 40 members in attendance. The discussion of the amendments to the By-Laws proposed at the meeting of the Club on September 17th, and brought up for discussion at the meeting on October 15th, was continued at this meeting. After several of the more important recommendations had been defeated, it was moved by the Secretary and carried that the entire list of amendments be rejected.

Business Meeting, November 5, 1910.—The meeting was called to order by President Easby at 8.45 p. m., with 118 members and visitors in attendance. The minutes of the business meeting of October 15th were approved as printed in abstract.

Following a report of the tellers, the President declared the following elected to membership: Active, Edward T. Grendlienard; Junior, George H. Borst.

Dr. Henry Leffmann, Active Member, presented the paper of the evening, entitled "The Building of a City," which was discussed by Messrs. J. M. Weiss, B. A. Haldeman, Henry Hess, W. C. Furber, J. E. Fulweiler, J. C. Trautwine, Jr., John C. Parker, D. K. Boyd, and others.

Mr. John C. Parker suggested that the Board of Directors appoint a committee to arrange for the holding of monthly meetings for the consideration of such municipal affairs as involve engineering, and, following this, it was moved and carried that the sense of the meeting was in favor of this suggestion.

Business Meeting, November 19, 1910.—The meeting was called to order by President Easby at 8.40 p. m., with 98 members and visitors in attendance. The minutes of the adjourned business meeting and of the business meeting held Saturday evening, November 5th, were approved as printed in abstract.

The president announced the death of Mr. J. Walter Ruddach; elected active member December 21, 1907, died November 6, 1910.

The Committee on Nominations presented the following list of nominations for officers of the Club for the year 1911:

| | |
|---|---|
| *President* | James Christie. |
| *Vice-President* | W. L. Plack. |
| *Directors* | St. George H. Cooke. |
| | R. G. Develin. |
| | Richard Gilpin. |
| | J. A. Vogleson. |
| *Secretary* | W. P. Taylor. |
| *Treasurer* | F. H. Stier. |

# ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS.

Regular Meeting, October 13, 1910.—Present: President Easby, Directors Ehlers, Cochrane, Plack, Swaab, Hutchinson, Mebus, the Secretary, and the Treasurer. The minutes of the regular meeting of September 16th were read and approved.

The Treasurer presented a brief report on the financial condition of the Club.

The Secretary reported that the contract with the accountants, C. W. Todd & Company, had been extended for a period of three months, to expire December 31, 1910.

The Committee on House reported that it had leased the meeting-room to the local sections of the American Chemical Society and the Institute of Electrical Engineers at stated times throughout the year, at a price of ten dollars a night and three dollars additional for the use of the lantern.

It was ordered that the President and Treasurer be authorized to negotiate a loan of one thousand dollars to be expended in improvements to and furnishings for the Club-house.

It was ordered that the trustees of the Bond Redemption Fund be authorized to cancel the second mortgage bonds owned by the Link Belt Company and held by the trustees, and that credit for this amount be placed upon the books of the Club.

The resignations of Messrs. H. McM. Dibert and Charles H. Ott were accepted as of July 1, 1910.

Regular Meeting, November 17, 1910.—Present: President Easby, Vice-Presidents Christie and Hess, Directors Ehlers, Cochrane, Plack, Swaab, Mebus, Wood, Halstead, Worley, the Secretary, and the Treasurer. The minutes of the regular meeting of October 13th were read and approved.

The Treasurer presented an informal report on the financial condition of the Club.

Mr. Charles F. Knight was reinstated to active membership.

The resignations of Messrs. William J. Cooper and A. Warren Way were accepted as of even date.

Mr. John C. Parker's suggestion, made at the last regular meeting of the Club, tha a committee be appointed to arrange for the holding of meetings for the consideration of municipal affairs, was referred to the Committee on Meetings.

The Building Committee presented a progress report.

Regular Meeting, December 15, 1910.—Present: President Easby, Vice-President Christie, Directors Ehlers, Develin, Plack, Swaab, Wood, Halstead, Worley, the Secretary, and the Treasurer. The mintues of the regular meeting of November 17th and of the special meeting of November 26th were read and approved.

The work of the Executive Committee was discussed, and it was ordered that meetings of this Committee be held on January 7th at 7 P. M. and January 19th at 7 P. M.

A letter from Mr. Thomas C. McBride was read, tendering his resignation as Chairman of the Committee on Increase of Membership, and, following acceptance of Mr. McBride's resignation, Mr. Henry Hess was elected temporary chairman. It was ordered that this Committee on Increase of Membership be empowered to add to its number at its discretion.

The Building Committee presented its final report, which was accepted and ordered to be spread upon the minutes of the Club. The Building Committee was then discharged.

It was ordered that all donors of material to the Building Committee be endered the thanks of the Board.

It was moved and carried that the Treasurer and Chairman of the House Committee be instructed to obtain an inventory of the house furniture and fixtures.

It was ordered that the Trustees of the Bond Redemption Fund be invited to meet the Board at its next regular meeting, to consider a revision of the method of retiring the second mortgage bonds.

On motion of Mr. Worley, it was ordered that the Board express to the commanding officer of Company "B," Engineer Battalion, its appreciation of the standard of excellence maintained by that organization during the past year, as shown in the annual rating of the National Guard.

# THE ENGINEERS' CLUB OF PHILADELPHIA

1317 Spruce Street

## OFFICERS FOR 1910

*President*

WM. EASBY, JR.

*Vice-Presidents*

*Term Expires 1911*
JAMES CHRISTIE

*Term Expires 1912*
HENRY HESS

*Term Expires 1913*
CHARLES HEWITT

*Secretary*
W. P. TAYLOR

*Treasurer*
J. A. VOGLESON

*Directors*

| *Term Expires 1911* | *Term Expires 1912* | *Term Expires 1913* |
|---|---|---|
| H. P. COCHRANE | EDW'D S. HUTCHINSON | DAVID HALSTEAD |
| R. G. DEVELIN | CHARLES F. MEBUS | E. J. KERRICK |
| H. E. EHLERS | S. M. SWAAB | PERCY H. WILSON |
| W. L. PLACK | A. C. WOOD | F. K. WORLEY |

STANDING COMMITTEES OF BOARD OF DIRECTORS

*House*—W. L. Plack, H. P. Cochrane, P. H. Wilson, A. C. Wood, F. K. Worley.
*Meetings*—W. P. Taylor, Chas. Hewitt, A. C. Wood, S. M. Swaab.
*Membership*—Chas. Hewitt, James Christie, Chas. F. Mebus.
*Finance*—James Christie, H. E. Ehlers, Henry Hess.
*Publication*—Chas. F. Mebus, R. G. Develin, J. A. Vogleson.
*Library*—H. P. Cochrane, Edward S. Hutchinson, H. E. Ehlers.
*Publicity*—David Halstead, S. M. Swaab, W. P. Taylor.
*Advertising*—H. E. Ehlers, E. J. Kerrick, R. G. Develin.

MEETINGS

*Annual Meeting*—1st Saturday of February, at 8.15 P. M.

*Stated Meetings*—1st and 3d Saturdays of each month, at 8.15 P. M., except between the fourteenth days of June and September.

*Business Meetings*—When required by the By-Laws, when ordered by the President or Board of Directors, or on the written request of twenty-five Voting Members of the Club.

The Board of Directors meets on or before the 3d Saturday of each month, except June, July and August.

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.

NOTE.—The Club, as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. XXVIII. APRIL, 1911. No. 2

PRESIDENT'S ADDRESS.

# THE BEGINNINGS OF SANITARY SCIENCE AND THE DEVELOPMENT OF SEWERAGE AND SEWAGE DISPOSAL.

WILLIAM EASBY, JR.

*Annual Meeting, February 4, 1911.*

SANITARY science embraces all those branches of knowledge in which are considered special measures for the preservation and promotion of the health of individuals and communities. Of its constituents, medicine is perhaps the oldest and bacteriology the most recent. Sanitary engineering, regarded as a distinct branch, is a development of the last generation.

To fully appreciate the profound and wide-spread improvement in the general health of communities through the agency of clean water, clean food, clean air, and a medical science demanding the segregation of those sick of contagious diseases, we have but to turn through the pages of the history of civilization, where may be found records of devastating plagues, the victims of which are to be numbered by the millions. From the viewpoint of the present age, in which all occurrences are attributed to natural causes, and in which nothing is regarded as fortuitous or supernatural, it seems indeed strange that the primitive causes of this appalling waste of life were not generally recognized and their operation opposed by the medical

trickling beds has achieved a greater measure of success in the high-rate treatment of sewage than heretofore obtained.

Disposal by intermittent filtration on sandy tracts was probably first practised on a working scale by Baily-Denton, in Great Britain, as early as 1871, following experimental work in Germany and England which had been conducted for about five years preceding this date. By this process the bacterial oxidation of sewage by porous soils containing certain species of bacteria was fully demonstrated. It remained, however, for the Massachusetts State Board of Health, through its systematic and careful investigations, to give such prominence to the process as to command general attention. The publication in 1890 of a full report of the methods employed and results obtained with large experimental filters at Lawrence, Mass., showed that effluents of a high degree of purity, both chemical and bacterial, could be secured and at much higher rates than by irrigation, when the latter was conducted with proper regard for the quality of the effluent. Disposal by intermittent filtration is, generally speaking, available only where the proper sort of material occurs naturally, as artificial beds are far too expensive for economy except, possibly, where sandy and gravelly deposits are near the disposal site. Under carefully controlled operation, with filters properly constructed, nearly all organic matter is mineralized and a high percentage of the bacteria removed, the rate of filtration varying from 50,000 to 100,000 gallons per acre a day. Results as good as this cannot be obtained by any other practicable method yet discovered, but fortunately a much less degree of purification is often satisfactory.

The liquid wastes and excretal matter of communities have always, to some extent, found their way into streams and bodies of water, but the practice of disposal by dilution really began with the removal of such matter by water through extensive systems of city sewers. The intolerably unsanitary conditions attending this method, as usually practised, are well known, and, as we have seen, led in Great Britain and on the Continent to the development of land disposal.

The scientific establishment and general acceptance of the germ theory of disease in the last thirty years, as it relates to those diseases which affect the alimentary canal, must be regarded as marking another epoch in the history of sewerage and disposal. It explained the prevalence, at times, of typhoid fever, cholera, and other enteric diseases, and provided a rational basis for much that has been done empirically and for further progress.

[illegible] streams and bodies of water which have [illegible] purify themselves, but their ability to [illegible] and in large quantities has been [illegible] particularly true of most important [illegible] portions of sewage from towns or [illegible] their course. On the other hand, [illegible] disease through public water- [illegible] of the germ theory, has led [illegible] sewage effluents must closely [illegible] for filtered water-supplies. [illegible] of danger, this position [illegible] impracticable in its application [illegible] that few water-sheds, however [illegible] as sources of public water- [illegible] most surface-water supplies [illegible] view now gaining wide accept- [illegible] that, save for exceptional [illegible] does not render the recipient [illegible] any purpose except for drinking [illegible] regarded as satisfactory. This radical [illegible] with a change in practice, [illegible] has been permitted the coun- [illegible] progress of disposal by dilu- [illegible] the recognition of its most [illegible] factors involved shows that [illegible] must be sufficient for the pur- [illegible] that all oxygen is not [illegible] quantity depending largely on [illegible] winds, on temperature and [illegible] that there is an appar- [illegible] and a real purification result- [illegible] the end-products are nitrates. [illegible] in nearly all cases.

[illegible] sewage disposal came first [illegible] years ago, and in England. [illegible] on a working scale resulted from [illegible] which might be offered the Local Government Board [illegible] as a partial or as a complete substitute for land treatment, which, as already stated, was often poorly adapted to local conditions. The economic removal of sludge and

avoidance of ill odors where it is deposited have proved to be matters so difficult that it has been said the sewage disposal problem is the sludge problem. It was in an attempt to solve this problem that the septic tank was invented. Its early promises have not, however, been realized. Instead of liquefying and gasifying nearly all of the suspended organic matter, and also reducing some of that in solution, it has been found notably deficient in doing so in not a few installations, and where most successful the results have varied much with seasonal variations in the temperature, with the nature of the sewage, and with other conditions. Comparing the averages of a number of English tanks, the percentage of suspended matter removed ranges from 30 to 80, and it has been found that there is a progressive decrease in the proportion removed, as the accumulations in the bottom of the tank decrease the cross-section of the liquid above, thereby increasing the velocity through the tank. The discharge from the tank is not completely clarified, as much of the lighter flocculent solids are not settled out. By plain sedimentation the greatest removal of suspended solids does not exceed 80 per cent., which must be considered the maximum for the septic tank. Another claim made for the septic process is that it favors subsequent aërobic action, but this has not been established; in fact, the reverse seems to be the case. It seems to be the growing opinion that too little is known of the biochemic action which takes place in the septic tank to warrant the claim of its general availability or even of the constancy of results where already installed; indeed, there is evidence now that the claim of exclusive anaërobic conditions, on which so much stress has been placed, cannot be sustained, as tank effluents have at times contained dissolved oxygen. The preference is now for processes better understood and therefore more under control.

The contact treatment of sewage was developed in England on a working scale in 1893 at the London sewer outfalls at Barking and Crossness, being two years in advance of the practical use of the septic tank at Exeter, with which it has since been employed as a secondary and, in some cases, a finishing process. It may be regarded as an outgrowth of intermittent filtration established in this country by the Massachusetts State Board of Health about 1890, differing therefrom in the use of very coarse material in place of sand, with a consequent increase in the rate of from about 100,000 to 800,000 gallons, or more, per acre daily; and differing, further, in the retention of sewage in contact with the tank filling by closing the underdrains

instead of permitting it to pass continuously after each application. The contact period is inseparable from the use of coarse filling for the beds, as, without it, the large voids would permit the sewage to pass too quickly for purification. This, like other high-rate methods, gives an effluent which cannot compare favorably for purity with that from land treatment and filtration at their best, but the results meet the requirements in some places. A better purification may be had by passing the effluent to a second bed, and, for still better results, to a third, the rates for the whole area decreasing with each contact.

All of the factors influencing the efficiency of contact treatment have been investigated quite fully, covering the kind, size, and depth of filling materials; their original volume of voids and loss of volume with use, as well as the frequency of application of sewage and length of time required between such applications. The permanent loss of capacity of beds is the great defect of this system. The life of a bed is greatest when hard filling material is used and well clarified sewage is applied, intervals of rest being permitted for the oxidation of stored organic matter. The intermittency of the process, resulting in alternately anaërobic and aërobic conditions, is regarded as being fundamentally wrong, since the bacteria concerned in liquefaction and in oxidation require the maintenance of constant conditions for their most efficient work.

The greatest difficulty encountered in the use of the ordinary contact bed—the permanent loss of capacity—seems to have been successfully met by Dibden, by replacing the broken material used for filling, with slabs of slate laid in horizontal courses and separated by blocks of the same material, from one to two inches thick. In this way both the air space and capacity of beds is very much increased, the former leading to increased aërobic action. The freedom from permanent loss of capacity, beyond a certain point, and the restoration of the original capacity by flushing, which is favored by the separation of the slate slabs, has led to the construction of many of these beds in Great Britain, which have satisfactorily reduced the suspended solids, but those in solution are reduced less than in the beds employing the usual filling materials. A further very important advantage is the freedom of the deposits on the slate from offensiveness. It has been found that other organisms besides bacteria function in the purification effected, prominent among these being a small red worm which has been found in great numbers in all of the beds examined.

About twenty years ago the investigation of the Massachusetts State Board of Health at Lawrence showed that a high degree of purification could be attained with material as coarse as large gravel, if the rate was such that the sewage moved in thin films over the surface of the gravel, without filling the interstices. This principle is carried out in the trickling or percolating beds which are now used in several large plants in Great Britain, in Germany, and in this country. The tank filling generally used is, however, coarser than in the Lawrence tank, the rate much higher, and, as a result, the purification much less. Aërobic conditions are continuously maintained, and the oxygen of the air, the sewage, and the purifying organisms, which adhere to the tank material, are brought into the most intimate contact, an altogether ideal condition for aërobic purification, and one which has been sought by the introduction of air under pressure in beds of finer material with less satisfactory results, as in the experiments of Waring at Newport.

The employment of coarse filtering material renders the uniform distribution of the applied sewage difficult, since lateral flow, as in beds of finer material, does not take place to any extent, and it is therefore necessary to apply the sewage as a spray over the whole surface. This requirement is imperfectly met, either by traveling sprinklers, by revolving sprinklers, or by a multitude of fixed nozzles. As the purification efficiency suffers from non-uniformity of distribution, this feature of the design has been the subject of much experimentation. Trickling filters, like others, operate more successfully with settled than with raw sewage. The finely divided solids, which still remain in suspension after sedimentation, do not cause in them a permanent loss of capacity or clogging, as in contact beds and in filters of finer material. From causes not understood, trickling filters free themselves in warm weather from the organic matter accumulated in the winter, and thus obviate the great expense of removing, cleaning, and restoring the material with which the beds are filled, a consideration of the greatest importance in large installations. Non-putrescible effluents are obtained at rates varying usually from one to two million gallons per acre per day, which is three or four times as high as those obtained by double-contact treatment; furthermore, the effluent from the latter is not so well purified. Of all biologic methods of sewage disposal yet developed, the trickling bed seems the most promising. It is as well adapted to a wide range of climatic conditions as any, although there is some doubt of its success in very

PAPER NO. 1096.

# THE CHIEF ENGINEER AS INTERPRETER AND ARBITRATOR.

ALEX. SIMPSON, JR.
(Visitor.)

*Read November 19, 1910.*

IT is evident, in considering the engineer as an engineer in relation to construction work, that he may occupy any one, two, or three of three essentially different positions; and that the principles of law which appertain to each one of the three are entirely distinct from those which appertain to the other two. He may be considered in the light of a draftsman, as draftsman of plans and specifications, in which respect he is acting simply as an engineer, and the relationship between him and the owner or contractor for whom he draws the plans and specifications will be simply that of employer and employee, and the law of employer and employee will govern. He may be a superintendent of construction, or interpreter of the contract, in which case he acts as agent for the owner or contractor, and the law of principal and agent will govern. He may likewise be an arbitrator, required to determine whether all the terms of the contract have been complied with, and what amount, if anything, is due to the contractor for the work he has done, and in that respect he occupies a quasi-judicial position, and the law relating to judicial officers applies to him.

Of course, those three different classes may necessarily, and often do largely, run into each other. For instance, an engineer who is engaged in superintending, no matter how careful the draftsman may have been, often finds that certain matters have been overlooked, and he has to alter parts of the plans and specifications, or make entirely new ones to cover the omitted parts, and it is well within his rights to do so.

As the subject shows, this paper will deal almost entirely with interpretation and arbitration. There is one thing, however, which may be said on the subject of the draftsman before going to interpretation or arbitration.

One of the difficulties which lawyers have met with, when difficulties have arisen, has grown out of the fact that an indolent engineer has

meaning. Every trade has its customs, and while the specifications may seem plain enough, the courts proceed, according to the notions of those who know nothing about the particular trade, to err in their construction, because they interpret the specifications not according to the usual meaning of the words used, but according to their meaning in that particular trade. To illustrate: A contract in a case that came up in the Supreme Court within the last few months spoke of the fact that the stonemason was to be paid $2.50 per perch for the stone measured in the wall of a building. That seemed very simple, but the jury were advised that there was a trade custom (in Delaware County, Pa., where the contract was made) to have the stone measured in the wall according to what is known as mason's measure, which meant a great deal more than simply measuring the exact quantity of stone. It meant that every doorway and window was to be measured solid, and every angle was to be measured double, and according to that method the contractor was permitted to recover about one-third more than he would have been entitled to if the wall had been so measured as to determine simply the amount of stone that was there.

Another thing was decided in that case. The contract was to be performed in Delaware County, and the proof, which was there made, was that that was the custom in Delaware County; but inasmuch as the general contractor was a Philadelphian, it was decided that he could not be expected to know what were the local trade customs of Delaware County, and hence he was not bound thereby unless advised thereof before making his contract. The question to be determined on a retrial of the case was whether it was a general or a local custom; if it was general, it bound both parties, and was the law of the contract; if it was local, it was not the law of the contract, because not binding upon the Philadelphian.

So there are terms as distinguished from customs, simply trade terms, which have meanings distinct from their ordinary meaning. I was surprised some years ago in looking through an English report to find that there was a dispute as to what was meant by "a thousand rabbits." Now one would think that a thousand rabbits was a pretty easy thing to define, but it was held that when a man contracted to sell a thousand rabbits in a warren, he had to supply twelve hundred or he broke his contract. Perhaps the theory was that while there may be a thousand rabbits in a warren today, the Lord only knows how many will be there tomorrow.

known in the reports as Filbert vs. the city of Philadelphia, the contract provided for the construction of a reservoir according to certain plans and specifications, which were detailed at great length, as municipal specifications always are. It further provided that the reservoir should be a "complete and perfect reservoir, ready for use." When the reservoir was turned over to the city of Philadelphia, instead of being ready for use, it was found to leak badly, because underneath a part thereof there was a large quantity of micaceous rock. The city refused to pay because it was not a complete and perfect reservoir ready for use. But the court said that was not what the contract meant at all, but instead it meant that if, by a strict compliance with the plans and specifications, there could be produced a complete and perfect reservoir ready for use, the contractor must produce it; that he must not vary from the plans and specifications, because if he does he has not done the work which he contracts to do, and therefore cannot recover the contract price, even though he does thereby produce a reservoir which is ready for use. In that case the jury found that the work was done strictly according to the plans and specifications, and the contractor recovered the contract price, notwithstanding the leaky condition of the reservoir.

In the later case of Flintic Stone Co. vs. Mayor, etc., of New York, the contractor guaranteed that the reservoir would hold water; and in another case (Bush vs. Jones) in the Federal Court in this city, he guaranteed that water should not come into the building to be erected by him. In each of those cases the rule which has been stated was applied, notwithstanding the fact that the water leaked out in the one case and leaked in in the other, because the contractor had done exactly as he contracted to do, in building according to the plans and specifications.

In the cases thus given there was a seeming, if not an actual, conflict between the purpose to be attained and the actual clauses in the specifications; but the rule of reasonable construction applies even where there is no such conflict and the language used is plain in meaning. A single illustration must suffice. When the political break came in this city in 1905, there was a quantity of work being done on the filtration plants. One of the contracts was No. 25, which provided for the construction of fifty-five covered filters and a filtered water basin at Torresdale. The city, preliminarily to obtaining bids for the work, had certain borings made to show the character

to the qualifications above stated, it is the meaning of the words used, and not the intention of the man who drafts the specifications, that is to be taken into account, for not otherwise can the minds of the parties meet in making their contract. Were it not so the owner might say that he understood the words to mean one thing, and the contractor, that he understood them to mean another. Under such circumstances, who could decide between them? Manifestly only the meaning of the words used. And just here is where the engineer who was draftsman of the specifications, and is now interpreter thereof, commonly gets into trouble. As draftsman he knows that he intended the specifications to mean a certain thing, and therefore as engineer he says they mean that thing. Therein lies his error, for he is deciding not what they do mean, but what he intended them to mean, and that is not interpretation of the specifications at all.

Some time ago a well-known lawyer of this city argued before the Supreme Court as to the meaning of a certain act of assembly. He said to the court: "Your Honors, I know what this act means because I drew it myself"; to which the Chief Justice replied: "That is the reason you do not know what it means; you know what you intended it to mean, but what it does mean you do not know."

In going over specifications perhaps time after time, errors are found the last time which it was thought did not exist. In such cases one reads what one has in mind should be there instead of what is actually there. That is the experience of every man who reads his own composition. It is the rule, therefore, the necessary rule, that the meaning of the words must govern the construction, for the man who contracts on the specifications has just as much right to say what he intended the meaning should be as the man who drew the contract.

During the last session of the Legislature, the present Attorney-General drafted and had passed an Act of Assembly (Act June 1, 1909, P. L. 381) which provided that all clauses in contracts providing for arbitration should be void, except where the contracts were made by corporations vested with the power of eminent domain. In all other cases, notwithstanding the arbitral provisions, the parties were referred to the law to determine their rights. It is a grave question whether that act is worth the paper it is printed on. In the first place, the courts have been very careful in sustaining the inherent independent right of a person *sui juris* to make such contracts as he pleases, so long as they do not interfere with some public policy

end of the attempt at arbitration, because one cannot be forced to accept one of two arbitrators at the option of the opponent, when only one has been agreed upon, and the arbitration clause under such circumstances becomes absolutely valueless, and the parties are left to their actions at law. It is seen at once that this is correct, for otherwise the city might dismiss a competent arbitrator, and substitute in his place one found to be more complaisant, and thus the contractor be seriously wronged.

There is another thing which engineers, as arbitrators, attempt to do once in a while, which the law in no uncertain language says shall not be done, and it is this: It makes no difference how broad the arbitration clause may be, it may be as broad as language can make it, yet it cannot be stretched far enough to cover the errors of the arbitrator himself. If the engineer, who is acting as arbitrator, makes a blunder, he cannot settle that matter on the contractor by himself arbitrating it. The law will not permit the blunderer to thus wrong the contractor. The engineer must bear his own burdens, and the owner, whose agent he is, must, as between him and the contractor, bear those burdens because the engineer is his agent. So also these arbitral provisions will not be construed to cover any matter not clearly within their purview, for the reason that they forbid recourse to the ordinary courts of law to settle ordinary disputes, and that can only be done by a distinct provision to that effect.

Another thing that arbitrators sometimes forget is this: Before a single thing is done as arbitrator, one must give both sides reasonable notice of the time and place of hearing, and an opportunity to produce their evidence. If one of the parties then chooses to stay away, he is as much bound by the decision as the others who are present. But if no such opportunity to be heard is given, the decision amounts to nothing at all. The reason for that conclusion is obvious. At the root of all our jurisprudence, and as the basis of all our liberty, is the fact that no man shall be deprived of his life, liberty, or property without "due process of law," which always carries with it the opportunity to be heard before his rights are determined.

The right to be heard for the same reason applies to the usual provision in a contract which enables the owner to cancel the contract if the contractor does not proceed with his work in certain ways and at certain times, in accordance with certain notices which are required to be given to him. For illustration reference is again made to the filtration cases.

At the time of the political upheaval of 1905, there was in the office of Director of the Department of Public Works of this city an honest man—it may be thought strange, but it was so—and he was asked to cancel the filtration contracts without giving notice to the contractor. He refused to do it, and the result was that he was given to understand that his resignation would not be unacceptable. It was given and was accepted. Another director was appointed, and he canceled the contracts offhand. When he was asked whether or not it was true that he canceled those contracts without any notice to the contractor, and without even waiting until his signature on his oath of office was dry, he was compelled to admit it. The cancellation was set aside. Can one imagine any justice in taking away contracts for millions of dollars without giving the contractor an opportunity to be heard? No court would permit that, and it did not in that case, which resulted in a verdict against the city of Philadelphia for upwards of two million dollars.

There is another common clause in most contracts, providing that "no work shall be treated as additional or extra, unless it shall have been ordered in writing." To the great surprise of the arbitrating engineer, he not uncommonly finds that that is a provision which is capable of being waived by an oral agreement, just as much as any other provision, provided the waiver is clearly proved; and it should be so. If it were not so, then a clause which is inserted for the protection of the owner, instead of simply protecting him, would be wrested from its proper purpose to the injury of the contractor, and the law says that cannot be done. The engineer, if agent for the owner, may orally waive that provision just the same as the owner may, and the latter will be bound thereby. In all such cases the contractor may recover for his extra work, with the same effect as if it had been ordered in writing, and the arbitrating engineer is bound to give it to him.

Likewise there is generally a provision that the contract must be performed in accordance with its terms, which means simply substantial performance, a failure in comparatively unimportant details being held insufficient to defeat the contractor's right to be paid. On the other hand, a man who does not substantially perform a contract cannot recover anything, no matter how much work he does; unless the owner himself takes over the contract and completes it, and then the contractor recovers his contract price less what the owner has been compelled to pay to get it completed.

There is another common clause which says "all work must be

done to the approval and satisfaction of the engineer," and that has been a cause of much litigation. In some States it is held that if the contractor can satisfy a jury that he has completed his contract according to its terms, then that is the end of the provision requiring completion to the satisfaction of the engineer. That conclusion is grossly illogical, however, because under it the clause is an absolutely nugatory thing, and might as well have been omitted, for with it in or out the contractor could not recover unless he proved that he had substantially performed his contract according to its terms.

In the case of Singerly vs. Thayer, the judge of the Court of Common Pleas said that such a clause is fully complied with, if what the contractor did, should have satisfied the engineer. But surely that is not the test, and should not be, for it substitutes for the contractual provision that the engineer shall be satisfied, one that the jury shall be satisfied, to which the parties did not agree. The true rule must be the one that the contract provides for, viz., the contractor must satisfy the engineer that the work is done according to plans and specifications. This does not enable the engineer, through caprice or fraud or anything similar, to cheat the contractor. Under such circumstances, if the contractor can satisfy the court and jury that the engineer is satisfied, but simply refuses to express his satisfaction, or through any wrongful motive refuses to examine the work or to be satisfied with it, he (the contractor) can recover, just as he would if the engineer had expressed his satisfaction. Here again the law refuses to permit a protective clause to be wrested from its intended purpose to the injury of another.

There was another point which arose in the filtration case, which is met with from time to time. In that case several of the contracts provided that the work was to be finished in so many working days, and the question arose, What is the meaning of "working days"? Of course, those words may mean either every day except Sundays and holidays, or they may mean every day in which the particular work contracted can be done. In the law they sometimes mean one thing, and sometimes the other. In the unloading of vessels, for instance, where demurrage, wharfage, etc., are very expensive items, and the work can be done every day whether it rains or not, "working days" mean every day but Sundays and holidays. But in unloading salt, by the custom of that trade, they only mean days on which it is possible to unload without injury to the salt. So in the filtration

forty years ago they started to burn this material, and today nearly all of the English cities burn all their refuse in high-temperature furnaces. In a few cities of France, Belgium, and Germany they are likewise using this method. Rotterdam is now building a large plant of this kind. There is no odor from these high-temperature furnaces. The fires must be so arranged and the mixture must be such that the temperature is at least 1200 or 1300 degrees Fahrenheit, and generally averages 1500 degrees, at which temperature the offensive matter is completely destroyed, and practically nothing is left but carbon dioxid and monoxid, which come out of the chimney, and nothing but clinkers and ashes are left on the grates. The high temperature produces steam, which pays for about half the cost of the destruction. All the refuse is burned without any nuisance being created.

chamber and thereby causes fresh masses of sludge to be subjected to bacterial action.

Fig. 6 shows a cross-section of the experimental tank at the Spring Garden testing station. The sludge withdrawn from this tank contained on an average 82 per cent. moisture, but it is believed that from the Emscher tanks which are being constructed at the Pennypack Creek sewage disposal works sludge will be obtained containing as low as 75 per cent. moisture. The importance of obtaining sludge

SECTION THROUGH CENTER OF EMSCHER TANK

FIG. 6.

low in moisture will be evident when it is considered that from the same amount of dry solids sludge 90 per cent. moisture is twice the bulk of that containing 80 per cent. moisture, and sludge 95 per cent. moisture occupies four times the volume of sludge 80 per cent. moisture.

The sludge withdrawn from an Emscher tank contains a large quantity of marsh gas or methane, which gas, when relieved from the

The following papers have been presented before the Club:

*January 4*—"The Destructive Effect of Motor Traffic on Road Surfaces, and Methods of Construction to Prevent It." W. H. Fulweiler (Active Member).

*January 15*—"The Disinfection of Water and Sewage." Earle B. Phelps (Visitor).

*February 5*—Annual Address—"Recent Developments in Engineering Practice." President W. P. Dallett.

*February 19*—"Some Notes on Wood Preservation and Creosote Production Abroad." Ernest A. Sterling (Active Member).

*March 5*—"A Labor-Saving Corporation and a Profit-Sharing Corporation." John C. Parker (Active Member).

*March 19*—"The Principles Involved in the Design, Construction and Operation of Submarine Vessels." Simon Lake (Visitor).

*April 2*—"The Economic Value of Motion Study in the Trades." Frank B. Gilbreth (Visitor).

*April 16*—"The Development of Correct Notions as to the Form and Position of the Earth." Henry Leffmann (Active Member).

*April 30*—"A Trip Across Panama; Life and Conditions on the Canal Zone." Martin Nixon-Miller (Active Member).

*May 7*—"The Fruhling Suction Dredge." John Reid (Visitor).

*May 21*—"An Automatic Signal for Electric Railways." Carl P. Nachod (Active Member).

*June 4*—"The Construction of a Rapid Transit Railroad in Relation to the Handling of Passengers." J. Vipond Davies (Visitor).

*September 17*—"The Design and Operation of a Modern Classification Yard." W. A. MacCart (Visitor).

*October 1*—"Smoke Abatement." D. T. Randall (Visitor).

*October 15*—"Military Engineering." Curtis W. Otwell (Visitor).

*November 5*—"The Building of a City." Henry Leffmann (Active Member).

*November 19*—"The Chief Engineer as Interpreter and Arbitrator." Alexander Simpson, Jr. (Visitor).

*December 3*—"The Erie Railroad Four-Track Cut and Tunnel Line Through Bergen Hill, Jersey City." A. L. Moorshead (Visitor).

*December 17*—"Some Late European Experiences in Water and Sewage Works and Refuse Destruction." Rudolph Hering (Active Member).

The Junior Section held four meetings, the last being in April. Following this last meeting, the Juniors met and decided to postpone further meetings of the Section indefinitely, most of them being unable to attend both the meetings of the Section and the regular meetings of the Club, and preferring to confine their efforts to attendance at the regular Club meetings. No attempt has been made during the present winter to reorganize the Junior Section.

A reception and dance on April 25 and a smoker on November 7 each had an attendance of about two hundred and fifty members and guests. The expense of both functions was met by subscriptions from members of the Club, and both accounts showed a credit balance which has been used to defray the expenses of Club nights, held each Monday evening.

The Board of Directors, at its meeting on May 19, recognizing the necessity of making certain alterations and improvements to the Club House, passed a resolution, authorizing the negotiation of a loan of eighty-five hundred dollars

to be raised for this purpose, the amount of the loan being subsequently raised, by resolution, to ninety-five hundred dollars. These improvements included the following:

The fourth floor of the rear building, formerly occupied as office and library, was divided with partitions, creating six additional bedrooms and one bathroom. The library was moved to the second-story, occupying the former billiard room. The billiard tables were moved to the front basement, occupying part of a room used also as a rathskeller and cardroom. The general office was concentrated on the first floor. The enclosing walls of the rear parlor were removed, throwing that entire space into a large lobby, and, finally, a modern steam-heating plant was installed, replacing two old-fashioned hot-air furnaces.

In addition to the alterations and improvements in the building, the expenditures of the Building Committee included the purchase of furniture for the new rooms, rugs in the lobby, the repainting of the entire house, and several other miscellaneous improvements.

The financial report of the Building Committee having charge of this work is appended herewith. The returns from these improvements for the last three months have exceeded an annual rate of 10 per cent. on the investment, and the desirability of these improvements has been shown by the fact that the patronage of the house has increased by over 50 per cent. compared with a corresponding period last year.

## BUILDING ACCOUNT.

### Summary of Expenditures.

| | |
|---|---|
| Pay-roll of laborers | $1,945.41 |
| Bills paid up to December 1, 1910 | 3,846.84 |
| Bills certified up to December 28, 1910 | 1,066.86 |
| Bills due | 1,540.89 |
| Notes issued | 1,100.00 |
| | $9,500.00 |

### Summary of Receipts.

| | |
|---|---|
| *Cash Received:* | |
| Loans from members secured by notes at 5 per cent | $7,600.00 |
| Sale of junk | 32.53 |
| Interest on deposits | 6.70 |
| | $7,639.23 |
| Expenditures on vouchers drawn to December 26 | 6,627.23 |
| Cash in bank | $1,012.00 |
| Amount necessary to meet entire obligations | $1,860.77 |
| Amount necessary to meet bills due | $768.70 |

Owing to the confusion incident to the building improvements, the library has not been given the attention that is desirable, and the only expense incurred has been for the binding of periodicals. It is hoped, however, that funds will be available during the coming year for its improvement.

The Publication Committee reports difficulty in preparing for publication the informal remarks made by members in the meetings, and suggests that it would be desirable for members to present written discussions to the papers whenever

possible. As the standing of the Club outside of Philadelphia is judged largely by the character of its publication, the committee is anxious to improve it as much as possible, and will gladly entertain suggestions from members to this end.

## Financial Report.

The following is the report of the accountants and auditors who have had charge of the books of the Club:

STATEMENT OF ASSETS AND LIABILITIES
As at December 31, 1910.

ASSETS.

| | | |
|---|---|---|
| Cash—Colonial Trust Co.—Active Account | $623.62 | |
| Colonial Trust Co.—Interest Account | 1,534.11 | |
| In Office | 171.07 | $2,328.80 |
| Accounts Receivable, Members' Ledger | | 3,181.23 |
| *Inventory of Supplies on Hand.* | | |
| Wines and Liquors | $251.23 | |
| Cigars | 65.00 | |
| Fuel | 66.00 | |
| Restaurant—Provisions | 89.14 | 471.37 |
| *Property.* | | |
| Building No. 1317 Spruce street | $72,850.59 | |
| Furniture and Fixtures—House | 8,791.40 | |
| Furniture and Fixtures—Restaurant | 1,229.59 | |
| Library | 2,159.57 | $85,031.15 |
| *Insurance.* | | |
| Perpetual on Club House | $1,782.00 | |
| Unexpired on Furniture | 43.56 | 1,825.56 |
| *Miscellaneous.* | | |
| Bonds Deposited by Link Belt Engineering Co. | | $1,000.00 |
| Sinking Fund for Bond Redemption | | 403.39 |
| Total Assets | | $94,241.50 |
| *Liabilities.* | | |
| Accounts Payable | | $2,635.26 |
| Bills Payable | | 2,500.00 |
| Bills Payable—Building Account | | 9,500.00 |
| First Mortgage | $40,000.00 | |
| Second Mortgage Bonds | 26,750.00 | 66,750.00 |
| Accrued Interest—First Mortgage | 1,080.00 | |
| Accrued Interest—Second Mortgage Bonds | 1,527.50 | 2,607.50 |
| Carried forward | | $83,992.76 |

| | | |
|---|---|---|
| Brought forward | | $83,992.76 |
| Initiation Fees due Bond Reserve | | 730.00 |
| Reserve for Bond Redemption | | 403.39 |
| Link Belt Engineering Co.—Fund | | 820.00 |
| Reserve for Redemption of Link Belt Bonds | | 180.00 |
| J. A. Vogleson, Treasurer | | 93.22 |
| *Christmas Fund.* | | |
| Balance January 1, 1910 | $44.50 | |
| Contributions December, 1910 | 238.50 | |
| | $283.00 | |
| Disbursements December, 1910 | 250.00 | 33.00 |
| Total Liabilities | | $86,252.37 |
| *Surplus.* | | |
| Surplus as at January 1, 1910 | $3,315.57 | |
| Less Accounts charged off applying to prior periods | 83.45 | |
| | $3,232.12 | |
| Refund of Interest on Link Belt Bond | 100.00 | |
| Reserve for Bond Redemption Transferred upon cancellation of Bonds out of Sinking Fund | 3,250.00 | |
| Gain for Year 1910 as per Statement of Income and Expense | 1,407.01 | |
| Surplus as at December 31, 1910 | | 7,989.13 |
| | | $94,241.50 |

## STATEMENT OF INCOME AND EXPENSE
### Year Ending December 31, 1910.

INCOME.

| | | |
|---|---|---|
| Dues—Net | | $17,079.70 |
| *Publications.* | | |
| Advertising—Directory | $585.00 | |
| Advertising Proceedings | 775.55 | |
| Sales Proceedings | 169.25 | |
| Sales Directory | 3.00 | |
| Total from Publications | | 1,532.80 |
| *Miscellaneous.* | | |
| Interest on Deposits | 33.22 | |
| Rent of Meeting Room | 96.00 | |
| Reception Committee | 238.00 | |
| Credit for Interest on Perpetual Insurance | 89.16 | |
| Badge Sales | 32.00 | |
| Smoker Contribution | 22.95 | |
| Transfer from Girard National Bank Account | 85.04 | |
| Reprints | 17.40 | |
| Total Miscellaneous Income | | 613.77 |
| Carried forward | | $19,226.27 |

| | | | |
|---|---|---|---|
| Brought forward | | $19,226.27 | |
| ***Club-house Business.*** | | | |
| Restaurant Sales | $8,011.97 | | |
| Wine Sales | 1,024.85 | | |
| Cigar Sales | 1,268.45 | | |
| Billiards and Pool | 210.12 | | |
| Lodging | 2,607.41 | | |
| Total Income from Club House Business | | 13,122.80 | |
| Total Income Year ending December 31, 1910 | | | $32,349.07 |

### Expenses.

| | | |
|---|---|---|
| ***Salaries and Wages.*** | | |
| House Salaries and Wages | $2,746.36 | |
| Secretary's Office Salaries and Wages | 1,127.30 | |
| Treasurer's Office Salaries and Wages | 1,889.85 | |
| Restaurant, Salaries and Wages | 3,819.14 | |
| Total Salaries and Wages | | $9,582.65 |
| ***Expenses.*** | | |
| House Expense | $1,492.77 | |
| Secretary's Office Expense | 183.56 | |
| Treasurer's Office Expense | 233.47 | |
| Total Expense | | 1,909.80 |
| ***Publications.*** | | |
| Directory Publishing | $294.40 | |
| Proceedings Publishing | 1,295.44 | |
| Reprints | 57.85 | |
| Total Publications | | 1,647.69 |
| ***Miscellaneous.*** | | |
| Gas and Electric Light | $921.92 | |
| Telephones | 126.18 | |
| By-Laws Revision | 27.70 | |
| Club Luncheons | 396.00 | |
| Meetings | 483.04 | |
| Membership Committee | 143.87 | |
| Reception Committee | 225.22 | |
| Smoker | 26.65 | |
| Taxes and Water Rent | 927.90 | |
| State Tax on Bonds | 126.00 | |
| Insurance | 140.16 | |
| Badges | 33.00 | |
| Expenses Trustees' Bond Redemption Fund | 4.50 | |
| Total Miscellaneous Expense | | 3,582.14 |
| ***Interest and Discount.*** | | |
| Interest on First Mortgage | $2,160.00 | |
| Interest on Second Mortgage Bonds | 1,287.50 | |
| Discount on Notes | 75.83 | |
| Total Interest and Discount | | 3,523.33 |
| Carried forward | | $20,245.61 |

| | | | |
|---|---|---|---|
| Brought forward | | $20,245.61 | |

*Club-house Business.*

| | | | |
|---|---|---|---|
| Restaurant Purchases | $7,505.80 | | |
| Restaurant Supplies | 166.22 | | |
| Restaurant Ice | 202.16 | | |
| Restaurant Laundry | 219.98 | | |
| Restaurant Fuel | 271.53 | | |
| Restaurant Equipment | 54.39 | | |
| Restaurant Renewals and Breakages | 242.88 | $8,662.96 | |
| Wine Purchases | | 749.31 | |
| Cigar Purchases | | 990.22 | |
| | | $10,402.49 | |

*Inventory December 31, 1910.*

| | |
|---|---|
| Wines and Liquors | 251.23 |
| Cigars | 65.00 |
| Fuel | 66.00 |
| Restaurant Provisions | 89.14 |
| | $471.37 |

*Inventory January 1, 1910.*

| | | |
|---|---|---|
| Wines and Liquors | $188.89 | |
| Cigars | 64.84 | |
| Coal and Wood—House | 25.00 | |
| Restaurant—Provisions | 87.50 | |
| Restaurant Coal | 3.25 | $369.48 |

| | | | |
|---|---|---|---|
| Deduct Increase in Inventory | $101.89 | | |
| Total Club House Business, exclusive of Salaries and Wages | | $10,300.60 | |

*Depreciation.*

| | | | |
|---|---|---|---|
| Furniture and Fixtures—House | $331.13 | | |
| Furniture and Fixtures Restaurant | 64.72 | 395.85 | |
| Total Expense Year ending December 31, 1910 | | | $30,942.06 |
| Net Gain Year ending December 31, 1910 | | | 1,407.01 |
| | | | $32,349.07 |

Respectfully submitted,

J. A. Vogleson,
*Treasurer.*

The above report has been prepared by the accountants employed by the Club. The auditors have examined accounts taken at random and believe that the report as set forth above is correct. The bank balances are correct.

W. B. Riegner,
Wm. C. Kerr,
D. Robert Yarnall,
*Auditors.*

**The following is the report of the Trustees of the Bond Redemption Fund:**

**January 7, 1911.**

**Third Annual Report of the Trustees of the Bond Redemption Fund, being a statement of business for the year 1910:**

*Receipts.*

| | | | | |
|---|---|---|---|---|
| 1910. | | | | |
| January | 1. | Balance on hand | $560.14 | |
| January | 29. | Coupons collected | 5.00 | |
| February | 8. | Initiation fees | 275.00 | |
| March | 18. | Initiation fees | 155.00 | |
| July | 1. | Interest on deposit | 2.32 | |
| December | 2. | Initiation fees | 290.00 | |
| December | 31. | Interest on deposit | 1.48 | |
| | | | | $1,288.94 |

*Expenditures.*

| | | | | |
|---|---|---|---|---|
| January | 29. | Bond bought | $45.00 | |
| January | 31. | Bonds bought | 241.05 | |
| February | 8. | Bond bought | 495.00 | |
| March | 23. | Interest on Link Belt bonds refunded | 100.00 | |
| June | 15. | Box rent | 3.00 | |
| November | 22. | Notary's fee and postage | 1.50 | |
| | | | | 885.55 |
| | | Balance January 1, 1911 | | $403.39 |

The duties of the Trustees under paragraph first of item C, rule 2, of the provisions adopted by the Board of Directors March 21st, 1908, for the redemption of secured mortgage bonds, having been fulfilled, the Trustees proceeded to carry out the provisions of paragraph second, as amended by the Board of Directors January 4th, 1910, and advertised for offers for sale of second mortgage bonds. From offers received the Trustees purchased bonds to the par value of $800.00 and accrued interest for the gross sum of $781.05. By subsequent order of the Board of Directors these bonds, together with the bonds of the Link Belt Company, were cancelled, and all bonds, with cancelled unmatured coupons, were delivered to the Trust Officer of the Colonial Trust Company, trustee under the second mortgage. The Trustees, therefore, now hold no negotiable securities of the Club.

Respectfully submitted,

HENRY LEFFMANN,
EDWIN F. SMITH,
EDGAR MARBURG,
*Trustees.*

The Auditors have examined the Trustees' account and found it to be correct.

W. B. RIEGNER,
WM. C. KERR,
D. ROBERT YARNALL,
*Auditors.*

Respectfully submitted,

THE BOARD OF DIRECTORS,

WM. EASBY, JR.,
*President.*

W. P. TAYLOR,
*Secretary.*

# ABSTRACT OF MINUTES OF THE CLUB.

Business Meeting, January 7, 1911.—The meeting was called to order by President Easby at 8.35 p. m., with 124 members and visitors in attendance. The minutes of the regular meeting held Saturday, December 17th, were approved as printed in abstract.

The President announced that at an adjourned meeting of the Board of Directors held December 29, 1910, Dr. Edgar F. Smith, had been elected to Honorary Membership in the Club.

Following a report of the Tellers, the President declared the following elected to membership: Active, Walter Francis Drueding and William Mitchell Irish; Junior, Charles W. Bell, Boyle Irwin, Jr., Richard Coxe McCall, Arthur C. Merrill and George Justice Mitchell.

Mr. Thomas H. Wiggin, Visitor, presented the paper of the evening, entitled, "New York City's Additional Water Supply from the Catskill Mountains," which was discussed by Messrs. H. M. Chance, C. P. Birkinbine, L. F. Rondinella, S. M. Swaab, Wm. Easby, Jr., and others.

On motion of Mr. Swaab, the thanks of the Club were extended to Mr. Wiggin for his interesting and instructive paper.

Special Meeting, January 13, 1911.—The meeting was called to order by President Easby at 8.30 p. m., with 118 members and visitors in attendance.

Mr. F. H. Newell, Director of the United States Reclamation Service, presented the paper of the evening, entitled, "Engineering Work of the Reclamation Service," which was illustrated by a number of exceptionally interesting lantern slides. Upon motion, the thanks of the Club were extended to Mr. Newell.

Regular Meeting, January 21, 1911.—The meeting was called to order by President Easby at 8.35 p. m., with 102 members and visitors in attendance. The minutes of the Business Meeting held Saturday, January 7th, were approved as printed in abstract.

Mr. Thomas W. Sears, visitor, presented the paper of the evening, entitled, "The Functions of the Landscape Architect in Connection with the Improvement of a City," which was discussed by Messrs. Andrew Wright Crawford, Leslie W. Miller, John C. Trautwine, Jr., Edward S. Hutchinson, John C. Parker, James Christie, B. A. Haldeman and others.

On motion of Mr. Swaab, the thanks of the Club were extended to Mr. Sears and to the visitors who contributed to the discussion.

Special Meeting, January 30, 1911.—The meeting was called to order by President Easby at 8.30 p. m., with about 30 members and visitors in attendance.

Prof. A. M. Christen presented the paper of the evening, entitled, "Esperanto: Its Benefit to the Engineer," and was followed by a general discussion in which a number of those present participated.

# ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS.

Regular Meeting, January 19, 1911.—Present: President Easby, Vice-Presidents Christie and Hewitt, Directors Ehlers, Develin, Swaab, Mebus, Halstead, Worley, the Secretary, and the Treasurer. The minutes of the Regular Meeting of December 15th and the Adjourned Meeting of December 29th were read and approved.

Dr. Henry Leffmann and Mr. Edwin F. Smith, members of the Trustees of the Bond Redemption Fund, were present at this meeting of the Board by invitation, and the question of the revision of the method of retirement of the second mortgage bonds was discussed. Following this discussion, it was ordered that Section 4, paragraph A, of the method of redeeming Club bonds, as adopted at the regular meeting of the Board on March 21, 1908, reading as follows, "It will be the duty of the Treasurer of the Club to pay to the Trustees monthly all initiation fees dating from January 1, 1908," be suspended until otherwise ordered, and to take effect as of May, 1910. It was further ordered that, in accordance with the provisions of paragraph C of this section, $105 be appropriated to the Trustees of the Bond Redemption Fund.

The Treasurer presented a statement of the financial condition of the Club, showing a net gain for 1910 of $1287.86.

The Secretary reported that thirteen members of the Club had been dropped for non-payment of dues.

The resignations of D. W. Horn and James C. Wobensmith, Active Members, were read and accepted as of January 1, 1911.

The report of the Executive Committee was read, approved, and ordered to be printed as the Annual Report of the Board of Directors for the year 1910.

The Third Annual Report of the Trustees of the Bond Redemption Fund was also read, approved, and ordered printed with the report of the Directors.

Following an informal discussion on several Club matters, the meeting adjourned, upon motion, at 10 P. M., on the call of the chair.

Organization Meeting, February 7, 1911.—Present: President Christie, Vice-Presidents Hess and Black, Directors Hutchinson, Swaab, Wilson, Worley, Cooke, Develin, Gilpin, Vogleson, the Secretary, and the Treasurer.

The President then appointed the following to serve as standing committees for the ensuing year:

*House:* F. K. Worley, David Halstead, W. L. Plack, Richard Gilpin, W. P. Taylor.
*Meetings:* S. M. Swaab, Charles Hewitt, W. P. Taylor, J. A. Vogleson.
*Membership:* Charles Hewitt, Charles F. Mebus, R. G. Develin.
*Finance:* J. A. Vogleson, Henry Hess, Edward S. Hutchinson.
*Publication:* Charles F. Mebus, St. George H. Cooke, A. C. Wood.
*Library:* W. L. Plack, Richard Gilpin, E. J. Kerrick, P. H. Wilson.
*Publicity:* Henry Hess, David Halstead, F. H. Stier.
*Advertising:* R. G. Develin, H. F. Stier, P. H. Wilson.

The following were then elected by the Board to serve as Tellers and Auditors:

*Tellers:* Edwin M. Evans, E. J. Dauner, Alan Corson.
*Alternate Tellers:* G. Wise, Morton M. Price, Herbert Rice.
*Auditors:* W. B. Riegner, William C. Kerr, D. Robert Yarnall.

The following special committees were then appointed:

*Committee on Increase of Membership:* Wm. Easby, Jr., Chairman, Henry Hess, W. P. Dallett, H. H. Quimby, S. M. Swaab, D. Robert Yarnall. This committee was authorized to alter its membership, at its discretion.
*Art Committee:* W. L. Plack, Chairman, David Halstead, St. George H. Cooke.
*Committee on Licensing Engineers:* Dr. Edgar Marburg, Chairman, John Birkinbine, W. P. Taylor, was continued.

Mr. W. L. Plack, Chairman, S. M. Swaab, and J. A. Vogleson were appointed a special committee to consider and draft a resolution indorsing the efforts being made to establish uniform building laws throughout the United States.

Mr. Henry Hess, Chairman, J. A. Vogleson, and Richard Gilpin were appointed a special committee to consider ways and means for the formation of a committee to consider the standardization of engineering elements, said committee to report at the next meeting of the Board.

The salaries of the Secretary and Treasurer were fixed at $416 and $130 a year, respectively.

The Secretary presented an informal report on the financial condition of the Club.

Following the reading of a letter from Mr. S. H. Wright, relative to the Junior Section, it was ordered that a meeting of this Section be called for Saturday evening, February 18th, at 8 o'clock, to consider the future of the Section.

A letter from Mr. William R. Webster, relative to the licensing of engineers, was referred to the special committee of the Club on this subject, to report at the next meeting of the Board.

A letter from the Secretary of the Engineers' Club of Brooklyn, relative to an exchange of visits between the clubs of Brooklyn and Philadelphia, was read and referred to the entertainment division of the Committee on House, with the recommendation of the Board that these visits be arranged, if possible.

Mr. F. K. Worley was, upon motion, transferred from Associate to Active membership.

It was ordered that the regular meetings of the Board for the year 1911 be held on the Thursday evening preceding the third Saturday of the month.

Regular Meeting, March 16, 1911.—Present: President Christie, Vice-Presidents Hewitt and Plack, Directors Mebus, Swaab, Halstead, Worley, Cooke, Gilpin, the Secretary, and the Treasurer. The minutes of the Organization Meeting of the Board held February 7, 1911, were read and approved.

The Secretary presented a statement of the financial condition of the Club for the first two months of 1911, which showed a net gain in surplus of $239.74 for the two months.

A list of members delinquent in dues and house charges was read and, after discussion, the following resolution was passed:

"House charges incurred during any month are due on the first day of the month following. If these house accounts are not paid by the fifteenth of that month, the credit of the member will be stopped. If the account is not paid by the first of the following month, the member's name and the amount of his obligation will be posted on the bulletin board. There will be positively no exception to this rule."

It was further ordered that all members delinquent in payment of dues be posted in the Club-house two months after the delinquency is incurred, unless extension of time for payment shall have been granted by the Board. It was further ordered that this resolution be printed and sent to each member of the Club.

Messrs. J. W. Mackay and Henry Longcope were dropped from the rolls for non-payment of dues.

The following resignations were read and accepted: Alfred Kauffmann, A. B. Eddowes, M. M. Borden, Adam Laidlaw, E. R. Snyder, O. M. Milligan, F. C. Hubley.

A letter from Mr. Herbert Rice, declining the election to office of Alternate Teller, was read and accepted. Mr. L. R. Ferguson was then elected Alternate Teller in his place.

A letter from Dr. Henry Leffmann, Chairman of the Trustees of the Bond Redemption Fund, was read and ordered to be filed.

A letter from the Chairman of the Convention Section of the Engineers' Society of Pennsylvania, asking whether the Engineers' Club of Philadelphia desired to organize a Convention of this Society for the coming year, was read, and it was decided that this Club did not desire this Convention this year.

A report of the Committee on the Licensing of Engineers was read, and it was ordered that action in this matter be deferred until the Joint Committee of the Pennsylvania Engineering Societies had presented its recommendations.

A letter from the President of the Chamber of Commerce of Pittsburg, requesting action of the Club on certain bills before the State Legislature, was read, and it was decided that no action in this matter should be taken.

The Committee on House was authorized to solicit and collect subscriptions for a Ladies' Night, to be held April 24, 1911, and the Chairman of the Committee on House was authorized to increase his Committee by appointment of not more than two members.

# THE ENGINEERS' CLUB OF PHILADELPHIA

**1317 Spruce Street**

## OFFICERS FOR 1911

*President*
JAMES CHRISTIE

*Vice-Presidents*

| *Term Expires 1912* | *Term Expires 1913* | *Term Expires 1914* |
|---|---|---|
| HENRY HESS | CHARLES HEWITT | W. L. PLACK |

| *Secretary* | *Treasurer* |
|---|---|
| W. P. TAYLOR | F. H. STIER |

*Directors*

| *Term Expires 1912* | *Term Expires 1913* | *Term Expires 1914* |
|---|---|---|
| EDW'D S. HUTCHINSON | DAVID HALSTEAD | ST. GEORGE H. COOKE |
| CHARLES F. MEBUS | E. J. KERRICK | R. G. DEVELIN |
| S. M. SWAAB | PERCY H. WILSON | RICHARD GILPIN |
| A. C. WOOD | F. K. WORLEY | J. A. VOGLESON |

### STANDING COMMITTEES OF BOARD OF DIRECTORS

*House*—F. K. Worley, David Halstead, W. L. Plack, Richard Gilpin, W. P. Taylor.
*Meetings*—S. M. Swaab, Chas. Hewitt, W. P. Taylor, J. A. Vogleson.
*Membership*—Chas. Hewitt, Chas. F. Mebus, R. G. Develin.
*Finance*—J. A. Vogleson, Henry Hess, Edward S. Hutchinson.
*Publication*—Chas. F. Mebus, St. George H. Cooke, A. C. Wood,
*Library*—W. L. Plack, Richard Gilpin, E. J. Kerrick, Percy H. Wilson.
*Publicity*—Henry Hess, David Halstead, F. H. Stier.
*Advertising*—R. G. Develin, F. H. Stier, Percy H. Wilson.

### MEETINGS

*Annual Meeting*—1st Saturday of February, at 8.15 P. M.

*Stated Meetings*—1st and 3d Saturdays of each month, at 8.15 P. M., except between the fourteenth days of June and September.

*Business Meetings*—When required by the By-Laws, when ordered by the President or Board of Directors, or on the written request of twenty-five Voting Members of the Club.

The Board of Directors meets on or before the 3d Saturday of each month, except June, July and August.

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.



Vol. XXVIII. JULY, 1911. No. 3

PAPER NO. 1098.

# NEW YORK CITY'S ADDITIONAL WATER SUPPLY FROM THE CATSKILL MOUNTAINS.

THOS. H. WIGGIN.
(Visitor.)

*Read January 7, 1911.*

A NEW aqueduct for New York City, capable of carrying more than 500,000,000 gallons daily, is under construction for the entire distance from the Catskill Mountains to the New York City line. A storage reservoir (Ashokan) in the Catskills, having a capacity of 130,000,000,000 gallons, or 250 days' supply for the whole City of Greater New York; another storage reservoir (Kensico), nearer the City, with a capacity of 40,000,000,000 gallons; and a distributing reservoir (Hillview), with a capacity of 900,000,000 gallons, are also under construction. Drawings and specifications for a deep tunnel extending the Catskill aqueduct through Bronx and Manhattan boroughs and into Brooklyn are ready for advertisement; and contracts for large pipe lines for carrying the new supply into the borough of Queens, Brooklyn, and Richmond, with a regulating reservoir in the latter, are partially prepared and will be let in time to receive the water from the tunnel, which will be of slower construction.

The total length of main aqueduct from Ashokan reservoir to Brooklyn is 110 miles, and the conduits through Queens, Brooklyn

and Richmond comprise 16 miles of pipe line, generally 66 inches in diameter, making a grand total of 126 miles. The total amount of the contracts for doing this work will probably be about $100,000,000, of which $71,000,000 is for work already under construction. Land and engineering and other contingent expenses are not included in this cost.

The work above referred to will provide an aqueduct of more than 500,000,000 gallons daily capacity,* but watershed capacity of only about 250,000,000 gallons daily. To complete the scheme sufficiently to use the aqueduct approximately to its full capacity, two other Catskill watersheds must be connected, viz., Rondout and Schoharie. Two main additional reservoirs of a combined capacity of about 40,000,000,000 gallons and two branch aqueducts aggregating upwards of 20 miles will be necessary to develop these sources. The cost of these additions is estimated at about $25,000,000.

The date at which the first addition will be needed depends on several factors which are difficult to predict. Thus all the present Brooklyn supply is pumped from wells at a large cost. Catskill water, once made available and not needed elsewhere, can be supplied to Brooklyn without cost, and it might be found cheaper, so long as the Catskill aqueduct remained adequate, to build some of the additional works in the Catskills earlier rather than pay cost of pumping in Brooklyn during the intervening period. Moreover, certain of these ground-waters have become too saline by overdraft.

Again, there is a large supply of ground-water in the eastern two-thirds of Long Island which remains undeveloped by reason of local opposition to enabling legislation. This water was by far the quickest available for New York City, and, with power, the Board of Water Supply would have developed it first to minimize danger of water famine. A removal of the legal obstacle to Long Island development might affect the date of additional Catskill development. Without further Long Island development the second Catskill source would be needed in about 1918, to give assurance of sufficient capacity to withstand a series of dry years.

The Catskill scheme includes provisions for constructing a filter plant whenever it seems advisable. A site has already been purchased, and a gate chamber is provided on the Catskill aqueduct for intercepting the flow and shunting the water to and from the filters.

* Except for about 6 miles of steel pipe siphons across valleys, where, for the purpose of deferring cost, only one pipe line, out of three lines required for the total capacity, is to be installed at present.

him of the inadequacy of the Croton system. One paper of considerable influence repeatedly shows pictures of water spilling over the existing Croton dam in spring, and explains how millions of dollars are being wasted in what it is pleased to call "the Catskill steal," alleging that much smaller sums spent in additional reservoirs on the Croton watershed would enable the escaping floods to be corraled and render said steal unnecessary. This allegation can be made in a newspaper headline so clearly that a whole city can understand it without even buying the paper, but an adequate answer to it, put with admirable conciseness, took more than three pages in "Engineering News."* It is therein shown by careful analysis that an expenditure of $150,000,000 for additional reservoirs would add only 47,000,000 gallons to the safe daily capacity, whereas the same expenditure on the Catskill supply will produce over 500,000,000 gallons additional daily.

Without duplicating the article referred to, a few facts may serve to make the conclusion more concrete that Croton watershed is already thoroughly developed. The average run-off for the years 1868 to 1909 inclusive was about 400,000,000 gallons daily, or 23.5 inches if reckoned on the whole watershed of 360 square miles. The run-off during the eighteen years 1869 to 1886 inclusive was low, averaging only 346,000,000 gallons daily (20.2 inches), or only 10,000,000 gallons daily in excess of the latest estimated safe yield (336 M.g.d. = 19.6 inches). The run-off during the next eighteen years, 1887 to 1904 inclusive, was generally high, averaging 449,000,000 gallons daily (26.2 inches). Evidently to increase the safe yield from 19.6 inches, now assumed, to the average of 23.5 inches run-off from 1868 to 1909 inclusive, would require at least storage enough to impound all the surplus in a period like that from 1887 to 1904, for subsequent use in a period like that from 1869 to 1886. This surplus is about 46 inches. The total storage capacity of reservoirs now on Croton watershed is only about 16.7 inches (104.5 billion gallons). These figures, dealing with only one of the factors entering into the figure for total storage, would indicate that at least triple the present storage would be required to add one-fifth to the safe yield. Moreover, evaporation from this enormously increased reservoir surface would largely reduce the assumed possible one-fifth gain in safe yield. The precise figures given in the article above

* See article by A. D. Flinn, Dept. Engr., Board of Water Supply, "Engineering News," Feb. 6, 1908, pp. 155–157, and June 17, 1909, p. 650.

watershed, a shed of about 119 square miles, which is west of the Hudson River about opposite Croton, and sell water to the city. This scheme was successfully opposed on financial and other grounds by Bird S. Coler, then Controller, aided by the Merchants' Association, Chamber of Commerce, and other bodies. The report on the whole New York supply made to Mr. Coler by Mr. John R. Freeman, who was employed by the former, is one of the most valuable ever written, and is invaluable to the student of New York city's waterworks. Mr. Freeman points out, among other things, the cheapness and plentifulness of a supply from the Hoosatonic River, but this scheme, though much cheaper than the Catskill, has never been actively pushed because a part of the shed is in Connecticut, thus involving an interstate arrangement.

The next important move was the appointment, in the Seth Low administration, of the Commission on Additional Water Supply, consisting of Prof. Wm. H. Burr, of Columbia University, Rudolph Hering, and John R. Freeman. This commission employed a large force of engineers during most of 1903, and recommended a supply drawn at first from the watersheds of Fishkill Creek, Wappinger Creek, and Roeliff Jansenkill in Putnam County, extended as necessary to the Esopus watershed in the Catskills. Reservoirs and a 500-million gallon aqueduct with branch feeders at its northern end, also a filter plant at Stormville, N. Y., near Fishkill Creek, were planned, and surveys, drawings, and specifications of a general nature well advanced, when the defeat of the Low or Citizens' Union administration and the election of the McClellan or Democratic administration stopped the work. An act of legislation was then passed at the behest of the people of Dutchess County forbidding New York City to take water from Dutchess County. It may be said, in passing, that if indications are trustworthy these same people are now sorry they objected, witnessing the profitable land sales and active business that have come to their friends across the Hudson.

Through the vigorous action of Mayor McClellan and the continued interest of the Merchants' Association, the Chamber of Commerce and other enlightened (and, it may be admitted for the satisfaction of the average citizen's pessimism probably some not wholly disinterested) persons, the present non-partisan Board of Water Supply was created by the legislature on June 3, 1905. Mayor McClellan at first desired a provision in the act which would place the appointing power in the hands of the Chamber of Commerce, Manufacturers'

| | |
|---|---|
| Railroad to be relocated...... | 11 miles |
| Highways to be discontinued.. | 64 miles |
| Highways to be built......... | 35 miles |
| Bridges to be built........... | 9 miles |
| Material to be excavated ..... | 2,468,000 cu. yds. |
| Embankment to be placed .... | 8,025,000 cu. yds. |
| Masonry to be placed........ | 820,000 cu. yds. |
| Number of men employed..... | 3,000 |

Ninety billion gallons of the capacity of Ashokan reservoir is sufficient to furnish storage for the development to an economic point * of the Esopus watershed. The balance of its capacity will form a part of the storage for Schoharie watershed, since this part of its necessary storage can be obtained more cheaply by an excess in size of Ashokan reservoir than by a larger reservoir on that shed. The Ashokan reservoir may be used also to help out the storage on the Rondout and Catskill sheds by temporarily increasing the proportion of water drawn into the main aqueduct from those sheds.

*Olive Bridge Dam.*—The most important structure of the reservoir is Olive Bridge dam, the length of which is about 4800 feet, including 1000 feet all masonry and 3800 feet earth with masonry core wall. The maximum height of the masonry dam from bed-rock to top is 220 feet, not including a cut-off wall about 20 feet wide, which extends about 40 feet deeper. The masonry dam, like that at Boonton, N. J., and at Cross River and Croton Falls on the Croton shed, all built under Mr. J. Waldo Smith, is built of so-called Cyclopean masonry faced with concrete blocks. Fig. 2 shows a cross-section and Fig. 3 shows the comparative section of this and certain other well known dams. The comparatively liberal dimensions of Olive Bridge dam are due to assumption of an ice-pressure of 47,000 pounds per linear foot of dam and of upward water-pressure on two-thirds the area of horizontal planes, and varying from 0 at the toe to full head at the heel of the dam.

The most notable details of construction are the complete interior drainage above the level of the fill on the down-stream side and the use of expansion joints at intervals, generally 84 feet. The drainage is accomplished by embedding, 12 feet apart, in a nearly vertical plane about 15 feet from the up-stream face of the dam, stacks consisting of blocks of special porous concrete 3 feet square with an 18-inch hole in each, together forming in each stack a continuous nearly vertical hole 18 inches in diameter. These holes terminate

* Development is very high, viz., ten-year depletion basis, on account of cheapness of storage in Ashokan reservoir.

Fig. 3.

KENSICO RESERVOIR.

| | |
|---|---|
| Total capacity | 40,000,000,000 gallons |
| Capacity available without pumping | 28,000,000,000 gallons |
| Water surface | 717 acres |
| Land required | 3,184 acres |
| Elevation of water | 355 feet above tide |
| Maximum depth of water | 155 feet |
| Elevation of top of dam | 370 feet above tide |
| Maximum height of dam | 290 feet |
| Width of top of dam | 28 feet |
| Maximum width of dam | 230 feet |
| Length of dam | 1,830 feet |
| Materials to be excavated | 957,000 cu. yds. |
| Embankment to be placed | 1,188,000 cu. yds. |
| Masonry to be placed | 983,000 cu. yds. |
| Amount of Kensico dam contract | $7,953,000 |
| Highways to be discontinued | 16 miles |
| Highways to be built | 9 miles |
| Bridges to be built | 4 miles |

Kensico reservoir is so large as materially to simplify the problem of cleaning and repairing the aqueduct north and give security against interruption of supply from any but the most serious and practically unheard-of accident.

The main feature of the reservoir is the Kensico dam, 1830 feet long, and estimated to be 290 feet high at its maximum, not including cut-off wall. The excavation has not progressed yet, as the dam lies across what is now Kensico Lake, forming a part of the present supply for New York City, and temporary diversion works must first be completed. Kensico dam, being in the midst of the populous and growing suburban territory of Westchester County, will be made of more ornamental construction than the Olive Bridge dam at Ashokan reservoir, and the down-stream side will be faced with granite instead of with concrete blocks. The excess cost above that of a dam like that at Ashokan reservoir is about $750,000. The Kensico dam has the same special features for drainage and expansion joints as has the Olive Bridge dam.

*Hillview Reservoir.*—From Kensico reservoir there are 15 miles of aqueduct to Hillview reservoir, which is not far from the north boundary of the City.

Its function will be to equalize the differences between the use of water in the City as it varies from hour to hour and the steady flow in the great aqueduct, and to furnish large quantities of water upon immediate demand, as in a great conflagration. It will hold 900,000,000 gallons. The contract was let for $3,270,000. It is divided into two parts and a by-pass aqueduct is formed by a 12-foot

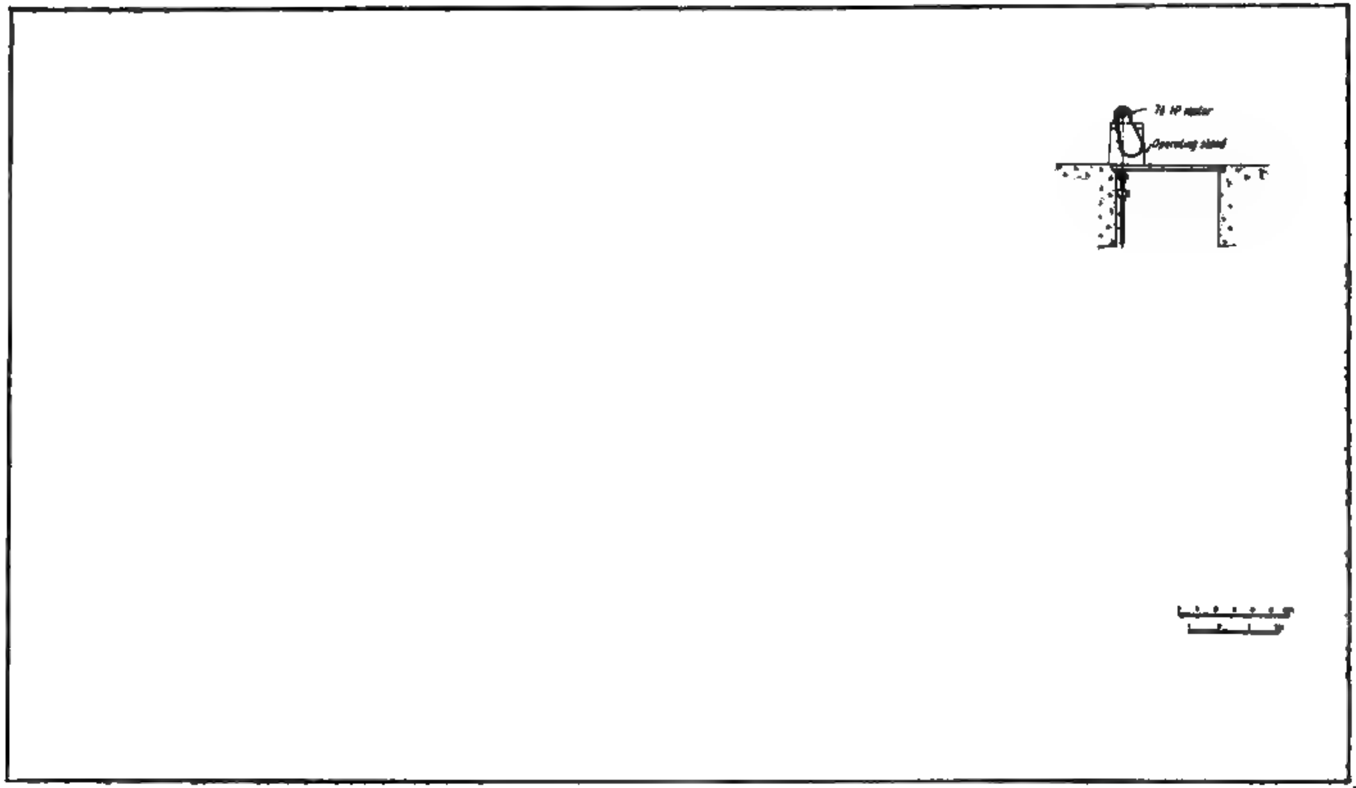


Fig. 5.—Special control gate of the needle type.

*(B) Kensico By-pass.*

| | Miles | Miles | Miles |
|---|---|---|---|
| 1. Reinforced concrete aqueduct, 11′ 0″ diam., 35′ max. head* | 2.2 | .. | .. |
| 2. "Grade" tunnel, horseshoe 11′ 0″ high x 10′ 9″ wide | 0.3 | 2.5 | .. |

*(C) Kensico Reservoir, Upper Effluent Gate-chamber to Filter Connection Chamber.*

| | | | |
|---|---|---|---|
| 1. Reinforced concrete aque., 17′ 0″ diam. containing 1 Venturi meter with 7′ 9″ throat, 40′ max. head* | 0.43 | .. | .. |
| 2. Reinforced horseshoe aque., 17′ 0″ high x 13′ 4″ wide, max. head* | 0.07 | .. | .. |
| 3. "Grade" tunnel, horseshoe, 17′ 0″ x 13′ 4″ wide | 1.5 | .. | .. |
| 4. Riveted steel pipe, concrete-covered and mortar-lined, steel shell 9′ 9″ diam. | 0.31 | 2.3 | .. |

*(D) Filter Connection Chamber to Influent Gate-chamber at Hillview Reservoir.*

| | | | |
|---|---|---|---|
| 1. Plain concrete horseshoe "cut and cover" aque. 17′ 6″ high x 8′ 0″ wide | 7.4 | .. | .. |
| 2. "Grade" tunnel horseshoe 17′ 6″ high x 13′ 9″ wide | 0.63 | .. | .. |
| 3. "Pressure" tunnel, 16′ 7″ diam. | 2.53 | .. | .. |
| 4. Riveted steel pipe concrete-covered and mortar-lined; steel shell 11′ 3″ diam. | 1.58 | .. | .. |
| 5. Reinforced concrete siphon, 16′ 7″ diam., 12′ max. head* | 0.03 | 12.2 | .. |
| Total length of Aq., Ashokan Res. to Hillview Res. | | | 91.6 |
| *(E) Hillview Reservoir. By-pass = 12′ 0″ diam. void in concrete dividing wall* | | 0.5 | 0.5 |

II. City Aqueduct.

*(A) Hillview Reservoir to City Line.*

| | | | |
|---|---|---|---|
| "Pressure" tunnel, 15′ 0″ diam. | | 0.4 | .. |

*(B) City Line to Brooklyn Distributing Center.*

| | | | |
|---|---|---|---|
| 1. Pressure tunnel 15′ 0″ diam. | 7.37 | .. | .. |
| 2. " " 14′ 0″ " | 4.96 | .. | .. |
| 3. " " 13′ 0″ " | 0.86 | .. | .. |
| 4. " " 12′ 0″ " | 1.71 | .. | .. |
| 5. " " 11′ 0″ " | 2.52 | 17.4 | .. |
| *(C) Spur "Pressure Tunnel" line to Ft. Greene Park; 11′ 0″ diam.* | .. | 0.3 | .. |

*(D) Spur line to Richmond (Staten Island) via Brooklyn and The Narrows.*

| | | | |
|---|---|---|---|
| 1. 66″ steel pipe in Brooklyn | 3.23 | .. | .. |
| 2. 48″ cast-iron pipe in Brooklyn | 3.10 | .. | .. |
| 3. 36″ submerged flexible-jointed cast-iron pipe across The Narrows (ultimately two lines like this) | 1.86 | .. | .. |
| 4. 48″ cast-iron pipe in Richmond, from Narrows to Silver Lake Reservoir | 1.78 | 10.0 | .. |

* Maximum head measured to intrados of arch at crown.

*"Cut-and-cover" Aqueduct.*—The horseshoe-shaped aqueduct of plain concrete, built in open cut or on embankment, called for brevity "cut-and-cover" aqueduct, is by far the cheapest type; hence economic comparison of the many routes studied necessarily resulted in choice of locations having a maximum of the cut-and-cover type. As indicated in the table, pages 198 to 200, more than half of the aqueduct north of the city is of this type.

The invert is generally 16 inches thick and of sufficiently large radius in cross-section to permit screeding with moist concrete, *i. e.*, the slope at side walls is about 1 on 2½. The arch is of a basket-handle shape that follows closely the line of arch pressure obtained with assumptions of about one-third for ratio of horizontal to vertical earth loads. The arch is generally 12 inches thick at crown.

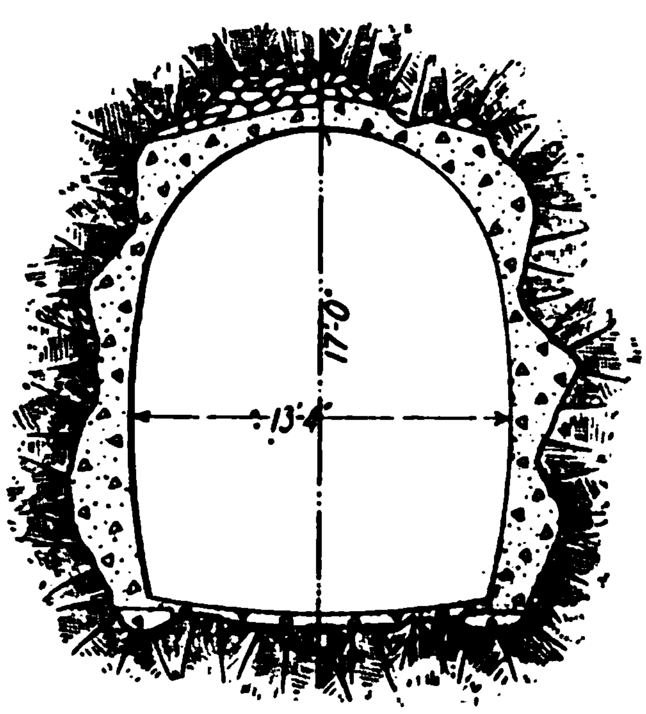



Fig. 8.—Grade tunnel.

Fig. 9 shows the steps in construction. The invert is screeded in length of 15 feet, and beneath the transverse joints, to intercept leakage, are blocks* of concrete 16 inches wide with smoothed tops. In rock cut, and in earth compact enough to take the thrust of the arch, the concrete is laid directly against the bank, thus omitting the toe of the side wall. In loose earth the side wall and arch are laid monolithic.

Transverse joints in side wall and arch occur at intervals from 15 to 75 feet, generally about 45 feet. Two types of transverse joint are still in competition,* viz., one with a steel plate embedded across

* Note, March 17, 1911: A decision has recently been reached, based on tests to date, to use steel plate 6" x ⅜" in side wall, arch, and invert during the coming year.

the joint, and the other made by carefully formed dovetailing of the concrete, especial attention being paid to smoothness of surface and "draw" to prevent keys from pulling apart instead of slipping.

A cut-and-cover aqueduct of such large size presents many complex problems as to accuracy, strength, and convenience of forms and handling of excavation and concrete. Those contractors who expected to evolve successful forms or methods out of their inner consciousness, without experimentation, were all disappointed so far as the writer knows, but sufficiently heavy and accurate forms and successful methods have now been developed.

*Grade Tunnel.*—Where one of the many divides is to be passed, or where following around a promontory makes a relatively great increase in length of cut-and-cover aqueduct, there is used a tunnel at the hydraulic gradient, called for brevity "grade" tunnel. There are twenty-four such tunnels, aggregating 13.6 miles, in the aqueduct from Ashokan reservoir to Hillview reservoir. The grade tunnel is of less waterway area than the cut-and-cover aqueduct, because there was some saving in making the more expensive types of construction of less size. It is made of the same height as the cut-and-cover aqueduct because possible air-trapping troubles could thus be avoided, and the high and relatively narrow tunnel was found probably to be as cheap per cubic yard as one of which height and width are more nearly equal.

For the crossing of the many valleys between Ashokan reservoir and Hillview reservoir, three types of construction are used, viz., "pressure" tunnel, steel pipe, and reinforced concrete aqueduct, each according to conditions.

*Pressure Tunnels.*—The Catskill aqueduct is unique in the number, length, and depth of the tunnels in rock which are to be used to carry high unbalanced internal water pressures. In the whole aqueduct north of Hillview there are seven * of these so-called "pressure" tunnels, aggregating about 17.4 miles, reached by shafts seldom less than 350 feet, and, in the case of the Hudson river crossing, 1150 feet, in depth. With the aqueduct in service, these tunnels carry unbalanced internal heads generally 200 feet or more, and in the case of the Hudson crossing, 410 feet. Much of the city aqueduct also is pressure tunnel; this is referred to later in the paper.

* Three of these, while named separately, are adjoining, and really form one long siphon.

of too doubtful quality; or so deep in proportion to the width of valley as to make the cost of the pressure tunnel prohibitive, due to a very large proportion of vertical shaft. For these, steel pipe was adopted, as also for certain lesser valleys, for reasons described further on, under "Reinforced Concrete Aqueduct."

The steel pipe siphons north of Hillview reservoir are fourteen in number and aggregate 6.2 miles. Each siphon will ultimately have three lines of pipe, two of which are deferred for the present. At the end of each steel pipe siphon is a housed-over chamber providing an easy junction between the single-grade aqueduct and the three pipe lines, and containing a bronze-mounted cast-iron sluicegate and stop-plank grooves at the head of each pipe.



Fig. 13.—Concrete-covered mortar-lined steel pipe. Steel shell 9′ 6″ diameter.

The construction (Fig. 13) is unique in that the steel pipes are both surrounded by an "aqueduct section" of concrete and lined with mortar, having a uniform diameter 4 inches less than the inner courses of the steel plate. This style of construction was actually found cheaper than plain steel pipe because the higher coefficient* of flow enabled three pipes of shipable size to do the work of four equal-sized unlined pipes; also a longer life† could be properly assumed. The specified method of lining, viz., by pouring 1 : 2

* Assumed 125 in Chezy formula, as against 85 for plain steel pipes.

† Seventy-five years *vs.* thirty-five for plain steel pipe.

able streams, including one of 250,000,000 gallons daily capacity a few miles north of Hillview reservoir.

*Gaging Manholes, Venturi Meters, Boat Holes.*—Five gaging manholes, arranged for current-meters, are provided at intervals along the aqueduct. A Venturi meter is placed in the aqueduct near Ashokan reservoir, another a little north of Kensico reservoir, and a third a little south of Kensico reservoir. A bronze casting about 1 foot long containing the up-stream pressure chamber, and a bronze casting about 7½ feet long at the throat, also containing the pressure chamber, are the only part of the meter tube not constructed of reinforced concrete. The tube and the throat diameter in two meters are 17.5 and 7.75 feet respectively, and in the third 17.0 and 7.75 feet.

A covered opening, usually 4.5 by 17.5 feet, to permit putting in and taking out a boat, is provided at each end of nearly every stretch of grade aqueduct.

*Slopes and Hydraulic Gradient.*—The controlling elevations of the hydraulic gradient and general slopes of various types of aqueduct are as follows:

NORTHERLY SECTION OF AQUEDUCT.

| | |
|---|---|
| Elev. of lowest fall draft from Ashokan reservoir, approx. | 511 |
| Elev. of ordinary high water in Kensico reservoir | 355 |
| Cut-and-cover aqueduct 17′ high x 17′ 6″ wide, slope * | = .00021 |
| Grade tunnel, 17′ high x 13′ 4″ wide, slope * | = .00037 |
| Pressure tunnel, 14′ 6″ diameter, slope | = .000615 |
| Pressure tunnel, 14′ 2″ diameter, slope | = .000687 |
| Pressure tunnel, 14′ 0″ diameter, slope | = .000729 |
| Steel pipe, 9′ 2″ inside lining, slope | = .00067 |
| Steel pipe, 9′ 5″ inside lining, slope | = .00059 |

KENSICO RESERVOIR TO FILTERS.

| | |
|---|---|
| Elev. lowest full draft from Kensico reservoir, approx. | 337 |
| Elev. of water on filters | 322 |

Aqueduct 17′ circular and 17 x 13′ 4″, all under head.
Slopes all special, as is also case for aqueduct just south of Ashokan reservoir, to allow for extra fouling near intakes.

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* These grade aqueducts are built to the slopes. For siphons the slope is in hydraulic gradient, and is used in addition to special losses at siphon chambers, etc., to fix total drop between siphon chambers. Following are some of special losses assumed: 90° curves $.15\frac{V^2}{2g}$, tee-shaped junctions $.33\frac{V^2}{2g}$, siphon chambers, .25 foot. Headworks losses are more considerable, but too numerous to list.

effect more or less well known. A large drill, small clearance of core barrel and of two or three following sections of rod (obtained by close setting of diamonds and frequent removal of core barrels and rods), and comparatively light pressures and high speeds are the usual precautions taken in drilling straight holes.

The first pair of holes under the Hudson River were purposely directed low, with the idea that they would curve upward; at the same time unusual precautions were taken to keep them as straight as possible, including the use of a very large hole—namely, 2¾ inches in diameter. These precautions were so successful that the holes were nearly straight, and it was found impossible to bend them up to the elevation required, though some upward curve was obtained by reducing the size of drill, first to about 2 inches and then to about 1⅜ inches. The second pair of holes was directed on the assumption that they would be straight, which proved to be the case, no effort being made to bend them.

To test the direction of a hole, only one of the several devices invented is very satisfactory; that is a glass bottle with a solution of hydrofluoric acid, which will etch a horizon on the bottle. Frequently two or three bottles are used simultaneously in a test and the results averaged. Owing to capillary attraction, the horizon is not etched in a true horizontal plane, and an émpirical scale has to be determined by setting the tube at known angles and comparing corresponding angles measured from the horizon etched on the glass.

Only that portion of the drill rod which is near the drill is the same size as the hole drilled. The core barrel wears out very quickly and has to be watched. I have record of one hole entering the rock at a dip of 12 degrees and actually coming out of the ground in a length of 900 feet at a point 128 feet higher than the starting-point. Another hole 820 feet long changed its dip from 70 degrees at the start to 8 degrees. Many other records are available of holes changing nearly as much as this in direction.

Dr. H. M. Chance.—What was the final deflection from the original angle in the case of the Hudson River borings?

Mr. Wiggin.—The upper pair of holes started with a dip of a little more than 40 degrees. The one from the west shaft was about 2½ degrees steeper at mid-length, 3 degrees flatter at three-quarter length, ended about 2 degrees flatter and averaged about 1 degree flatter than at the beginning. The one from the east shaft was about 1 degree steeper at 500 feet, 5 degrees flatter at 1400 feet, ended about 4½ degrees flatter, and averaged nearly 2 degrees flatter than at the beginning. The upper or second pair of holes started at somewhat more than 23 degrees dip. Neither of them varied over 2 degrees from the original direction and both ended within 1 degree. These results are from a careful plotting of the deflection records rather than the records themselves. Individual readings probably show greater variation.

Dr. Chance.—How do you know that the hole does not reflect laterally?

Mr. Wiggin.—There were no means of determining the lateral deflection except by the way the bit acted. It seems, however, almost a certain inference in this case that the hole was at least as straight in a lateral plane as in a vertical plane, since the vertical plane has the main factor which produces deflection. In any case it would require considerable lateral deflection to greatly impair the value of the information.

I think, without exception, the Rondout siphon is the most difficult work

so far encountered. The Hudson River crossing is more spectacular, but there has never been much doubt in the engineers' minds of finding good conditions at some reasonable depth, and mere depth is not an important difficulty. The rock at the Hudson crossing is a beautiful rock, solid granite (granitic gneiss), with no important weaknesses. There is good reason to hope that the rock will continue reasonably dry. The Rondout siphon comes through a very mixed country, geologically speaking. Some of the rock is faulty and very wet and will require careful treatment to prevent leakage, possibly steel interlining. Several caves in the rock, filled with clay-like material, were encountered.

PAPER No. 1099.

# A REVIEW OF THE PROGRESS OF CITY PLANNING.

B. ANTRIM HALDEMAN.

(Active Member.)

*Read March 18, 1911.* 91

THE "city plan," as generally understood, deals chiefly with the street system, but in a broader sense it also includes, or should include, the distribution of parks, squares, playgrounds, and other open public places, the improvement of the water-fronts and all other public property which may be entirely subject to municipal control. The "city plan" is the foundation and framework upon which the city is built, and its character affects, directly or indirectly, every department of the city government, every class of society, and every branch of industry and trade. But modern "city planning" goes much farther than this and has a far broader scope; it goes beyond streets and squares and involves every function of the city; it reaches the homes and the health, the work and the play, of the community; it aims toward the systematic co-ordination and development of the physical features and the social forces of the city in a manner which shall give greater encouragement and larger opportunity for every legitimate enterprise and ambition of its people; it is altruistic in its intent, and its ultimate object is the making of better citizens as well as better cities; in its most comprehensive meaning and its broadest intent it involves so many and such varied physical and social elements that no one person can hope to solve, or to suggest solutions for, all of its problems. The planning of a modern city which shall fully satisfy all present needs and anticipate and meet the necessities of the future in any large degree demands the best service of the skill and genius of many professions, arts, and trades, no one of which, working alone, can accomplish great results, but all of which, working in co-operation, may achieve a large measure of success. Its social and economic problems do not directly concern the engineer, but his skill and wisdom are essential to the creation and intelligent development of those large constructive enterprises necessary to municipal progress and to the health, comfort, conve-

out regularly and rectangularly. In Rome we find the first great example of the replanning of a city upon a large scale. The Emperor Nero wearied of the rambling and chaotic conditions of the imperial city and was ambitious to undertake vast improvements; this he was unable to do by reason of the violent opposition of property owners and of the powerful priesthood, many of whose temples, shrines, and altars, which were innumerable and were esteemed sacred and inviolable, would have to be destroyed. To accomplish his purpose the emperor directed his architects to prepare elaborate plans for rebuilding the city and for housing and caring for the people whom the violent scheme he contemplated would make homeless for a time; then he applied the torch and began the horrible butchery of the Christians to distract the attention of the people and protect himself and his court from a fury which would otherwise have been directed against them. His device, extreme and awful though it was, succeeded, and Rome was recreated on a scale of great magnificence.

The evil days which fell successively upon Egypt, Greece, and Rome saw a violent decline in the arts of city building. Their splendid cities fell into decay with the nations which had created them, and those which rose upon their ruins reproduced but little of the grandeur and dignity of their stately predecessors.

During the Middle Ages, when the world was a battle-ground and only the law of the survival of the fittest prevailed, formal city building found no place in the activities of the feudal chiefs, who dwelt with their retainers in strong castles or walled cities which permitted but narrow opportunities for progressive or permanent development.

During the succeeding period, when the identity of nations was being established and their political boundaries were being formed, the perpetuation of the monarchical régimes which seized and held the reins of governmental power depended upon the control of masses of people, and there was a strong movement toward congregation in cities. But even during this period the recovery of the higher arts of civilization was very slow, and there was little improvement in the methods of city building except in the cases of towns laid out by kings and princes for royal residences or pleasure places.

The intense activity in the work of exploration, conquest, and colonization during the seventeenth century greatly increased the wealth of western Europe by opening new fields for industry and trade, and city building received a new and strong impulse. The arts of war

This movement has gathered force and increased in popularity until at the present time its scope embraces practically all our principal cities; its spread has been almost phenomenal during the past decade, and much earnest enthusiasm has attended its growth and much notable improvement has already resulted from it. It is difficult to say whether this movement was suggested by an appreciation of the wisdom of forestalling the further extension of the faults and evils which were rapidly becoming apparent in our methods of city building, or by the example set by European cities; but however that may be, it is true that our advocates of the new processes draw a large part of their inspiration from what has been actually accomplished abroad.

Whether the inspiration came from abroad or was conceived at home, most of the American cities have undertaken large projects of urban development and embellishment in a vigorous and determined manner. In many instances commissions of expert engineers and architects have been employed to make a comprehensive study of local conditions, prepare a general preliminary plan, and submit a report covering such suggested improvements as may seem feasible, adaptable, and broadly in the interest of the public welfare. In other instances state or municipal legislation has created local boards or commissions to perform similar services, and also to carry their recommendations into effect.

When William Penn founded Philadelphia, the dwellers in European cities still herded in the narrow streets and courts within the city walls; but even at that time the disadvantages of the prevailing conditions were becoming seriously realized, and Penn determined to adopt a radically different plan in laying out his new city. In this he was more foresighted than any of the contemporaneous pioneers of American city building, and his example was adopted and followed in the subsequent planning of most of our cities. The rectangular system, familiarly known as the "gridiron" or "checkerboard" system, which he adopted was a long step in advance of the systems which existed in the cities of his time. Although he had large faith in a great future for his new city, he could not foresee to what extent it was destined to grow or what would be its necessities in the years to come. If, in addition to the rectangular system of streets and parks he laid out, he had provided broad diagonal streets radiating from the square he established at the intersection of the two great avenues in the center of the city, and from the termini of High Street at the

ing of Delaware Avenue and the construction of modern wharves and bulkheads between Vine and South Streets. The banks of the Schuylkill within the boundaries of Fairmount Park have been improved in an attractive manner by the Commissioners of Fairmount Park, but along its lower courses, where opportunities are offered for an improvement which would be both useful and ornamental, nothing has been attempted; the improvement of that portion of the river was first suggested about fifteen years ago, and has been constantly agitated since that time, but nothing tangible has been accomplished beyond arousing and keeping alive a sentiment in favor of it.

All of these suggested projects for extending and improving the street system, for constructing embankments and broad commercial and ornamental avenues along the river banks, and for creating parks, parkways, and open public places, are closely related to each other in the common object of advantageous and attractive development, and general preliminary plans embracing all of them should be established by the proper authorities. The work necessary to carry such large projects of improvement into effect would, by reason of its cost, extend over a long period of time, and the existence of a well-considered comprehensive plan would insure its being done along systematic and uniform lines.

At the two great city planning exhibitions held in Berlin and London in 1910, which attracted engineers, architects, and other interested parties from all parts of the world, the United States was more largely represented than any country except Germany; nothing from Philadelphia was shown, but the new plans for Washington and Chicago were esteemed the finest and most magnificent of the entire collection. Reports as to the character of the exhibits, the attendance, and the interest shown in these events furnish conclusive evidence of a remarkable growth of activity and enthusiasm in the work of city planning in recent years; the comprehensiveness of the plans and the magnitude of the work contemplated by them indicate not only a sharp rivalry among cities for the material things that make for greatness, but also a quickened public sentiment and a determined public demand for the accomplishment of great purposes in great cities which not only expect to remain great but are ambitious to become still greater.

The people of the United States look eagerly forward to the time when Washington, in carrying out and completing the work contemplated by the plan for improvement she has adopted, will be the most

embellishment, and are busily engaged in doing the great things demanded by the pace of twentieth century progress. Philadelphia must take the same broad view of the responsibilities of the future, and in preparing a comprehensive plan for improvements is placing herself in the position of preparedness for the contest for commercial, industrial, and social supremacy of the coming years.

The fact that European cities are reconstructing their street systems upon modern and progressive lines, that their water fronts are in a high state of both useful and ornamental development, that they are constantly exerting themselves toward still greater civic improvement and civic attractiveness, and that many American cities are bending their energies in the same direction, may not be a sufficient reason why Philadelphia should do the same; but there are other and more potent reasons.

In the natural course of events a city knows no finality; barring any extraordinary violence of nature or of man, it goes on forever; its physical attributes, its progressiveness, its importance and influence as an industrial, financial, and political world-power, are what its citizens determine they shall be. In the days of absolutism cities were made great by the will of ambitious monarchs, and were kept great by equally powerful successors; but progressive modern governments have been emancipated from absolutism, and cities now achieve greatness only through the high ambition, concerted energy, and tireless activity of their loyal citizens. This being true, we must rely for rational and permanent progress upon the larger interest of the people and their broader view of civic problems.

A city can no more be the judge of its own greatness than an individual; it must keep in step with the world in the world's work, and it must win the world's acknowledgment and applause. To do this, it must aim toward higher ideals through every avenue of civic endeavor and civic duty, and it must pursue that aim with tireless energy and devotion. This is what the new departure in city planning means and stands for; it seeks not only finer streets, larger parks, and greater opportunities for industry, but it aims also to raise the standard of citizenship and to make city life more worth the living by providing for the improvement of the social condition and the environment of its people, and by creating a better, brighter, and more beautiful city for all.

Our people are too prone to be content with existing conditions and to give little heed to the call of the future, apparently forgetting the

"A city is the greatest of the works of art; written on its walls are the tradition and the history of the past, outlined in its composition is the imprint of the human soul. The city is a great stage, and city building is a real theatrical art. Mellowed in harmonious color and reflecting the soft blue of the sky, the effect of its sunlit walls is such as the most brilliant stage display can but poorly suggest. And yet it is but the background of the citizen who traverses its ways. Great is the city whose architecture is passed unnoticed by the crowd, but not unfelt. Great is its presentment when its more important buildings alone demand conscious attention, leaving the rest but subconsciously felt. Convincing is its merit when the persistent formality of its street is conducive to a sense of respect, and arouses in the heart of the citizen that pride of citizenship alone engendered by civic art.

"Democracy, with its new responsibilities, has grappled with the problems of its youth; it has made mistakes, it has to answer for far-reaching and most disastrous results, but it has passed through the fire. At first, intoxicated with the freedom it had won, it sought but mercenary gain. Cities became factories, and life merely a business concern. Sham respectability became a cloak for truth of expression, and what interest existed in civic design was centered around questions of construction and the importance of hygiene.

"But there has been a change; knowledge has spread, democracy has grown, the modern city awakes to a new dawn, and today it is the democracy who watch with anxiety the growth of towns.

"Most of our larger cities which have grown by leaps and bounds during the period of industrial activity of the latter half of the last century, require pulling down, Haussmannizing, and re-erecting on intelligent lines. This, then, is the work which the municipal authorities and the town planners of the future will be called upon to undertake, and it is in the carrying out of such undertakings that an appreciation of what ought to be will be found necessary before dealing with what is."

## DISCUSSION.

Leslie W. Miller (Visitor).—I cannot add anything whatever to this admirable presentation of this subject. I will say, however, that this is a presentation of the things that have got to be learned, of the lessons that have got to be applied, before a city with any pride at all can be satisfied with itself, and until those things have been learned, and until those lessons have been applied, you cannot be sure that you are on the right track. There is only one way of doing

then be the city beautiful, and if it is that it will also be the city healthful and the city happy. God hasten the day when Philadelphia will be the city beautiful of America.

JOHN C. TRAUTWINE, JR.—Nothing stands out more clearly, from Mr. Haldeman's paper, than the overwhelming advantages accruing from united effort, as distinguished from individual effort—the immeasurable superiority of public to private wealth.

At great cost, the millionaire may buy automobiles, great pictures, palaces, and other toys; but what are these, compared with the virtual ownership of all the street systems of all the world, which the poorest of us gets in return for a ridiculously small contribution to the common wealth?

One would suppose that, at this stage of the world's progress, every one would recognize these facts; yet, in a recent issue of a Philadelphia morning paper, a correspondent (manifestly a person of "wealth") broke out with the cry, "Taxes, taxes, nothing but taxes," and referred approvingly to "the great Christian statesman," Kaunitz, of Austria (who died more than a century ago), as having laid down the proposition "that the welfare of any nation did not depend on the income of the State but on the individual property of its inhabitants"; than which, as Mr. Haldeman's paper has shown us, nothing could be more preposterously contrary to the truth.

What is popularly known as the "barge canal" when completed will consist of four canals:

1. The Erie Canal, extending from the Hudson River at Waterford to Lake Erie at Buffalo.
2. The Oswego Canal, extending from the junction of the Oneida and Seneca Rivers through the Oswego River to Lake Ontario.
3. The Champlain Canal, extending up the Hudson River from Waterford to Fort Edward, then across country to Lake Champlain.
4. The Cayuga Canal, connecting the Erie Canal with Cayuga and Seneca Lakes.

The Erie Canal leaves the Hudson River at Waterford and ascends from the Hudson River to a point above the Cohoes Falls on the Mohawk River by a series of five locks. It then proceeds up the Mohawk River through a series of artificial lakes to a point near Utica. The route then passes across country to the head-waters of Wood Creek, down that creek to Oneida Lake, westward through Oneida Lake, down the Oneida River to its junction with the Seneca River. Proceeding westward, the canal ascends the Seneca River, Clyde River with its branches, to Fairport, about twelve miles east of Rochester. From this point the canal crosses the Arondequoit Creek valley, cuts through high ground to the Genesee, crosses that river, and proceeds westward, crossing various streams, to Lockport. From Lockport the canal cuts through a rock formation to the Tonawanda Creek, and follows that creek to its junction with the Niagara River at Tonawanda.

The elevation of the principal points on the Erie Canal above sea-level are as follows: Hudson River at Waterford, 14.5 feet; summit level near Rome, 420 feet; crossing of Oneida Lake, 369.89 feet; junction of the Seneca and Oneida Rivers, 363 feet; crossing of the Genesee River at Rochester, 512 feet; Niagara River at Tonawanda, 565.55 feet. It will be seen that the Erie Canal in passing across the State in a distance of 353.5 miles ascends from 14.5 feet to 565.55 feet above sea-level.

The Oswego Canal leaves the main canal at Three River Point at the junction of the Seneca and Oneida Rivers, passes north down the Oswego River to Lake Ontario, a distance of 22.6 miles, with a fall of 118.6 feet, to the lake.

The Champlain Canal rises from elevation 14.5 feet in the Hudson River at Waterford to elevation 140 feet on the summit level at

DELTA RESERVOIR.

| | |
|---|---|
| Capacity | 20,570,000,000 gallons. |
| Area of watershed | 137 sq. miles. |
| Area of reservoir | 4.33 sq. miles. |
| Height of dam from lowest point of foundation to crest | 100 ft. |
| Maximum depth of water at dam | 70 ft. |
| Average depth of reservoir | 23 ft. |

*Excavation.*—The total amount of excavation to be removed for the construction of the canal is estimated at 90,000,000 yards, of which about 10 per cent. is rock.

Many and varied types of excavating machinery are used on the various contracts. The stripping of embankment areas and other light excavation has been done on some contracts by the use of graders propelled by sixteen or twenty horses. Various types of drag scrapers, operated either from stationary towers or revolving derricks, are used. The maximum height of tower for this purpose is ninety feet.

Steam shovels of varying weights and capacities, with their necessary equipment of locomotives and cars, are in use. In drilling the rock, common forms of steam or compressed air drills are in general use, although on certain contracts well drills cutting holes varying in diameter from 2½ inches to 4 inches have been successfully operated. On Contract No. 1, in the Hudson River, the rock consists of shale, and is broken by a Lobnitz rock-breaking machine. This consists of a steel hammer 20 inches in diameter, 16 feet long, weighing about 16 tons. The hammer and the necessary machinery, boilers, etc., are carried in a large scow held in position by guy-lines to anchors or objects on shore. The hammer is suspended by a steel cable passing over a sheave attached to the drum of a hoisting engine.

The operation of the rock-breaker is as follows: The cables are fastened and the hammer brought over the ledge of rock to be attacked. The hammer is lifted about 6 feet and allowed to fall, the operation being repeated until the rock at the bottom is presumably shattered. The boat is then moved from two to four feet, and another hole drilled, it being assumed that the rock between the two holes is so shattered that it can be easily removed by a dipper dredge.

Hydraulic dredges are in use at various points on the canal; among others, on the Champlain Canal, Wood Creek, the Hudson River, Seneca, Oneida and Clyde Rivers, at the east end of Oneida Lake, and in Tonawanda Creek.

Most of the dredges have suction pipes 20 inches in diameter.

ing the drag bucket forward, getting a firm bite, and pulling on the drag line. The machine was designed to make thirty complete revolutions in an hour, which would mean the loading and discharging of one 5-yard skip every minute. In practice, owing to the natural limitations of the steam shovel, this rate cannot be attained, as the shovel cannot equal the capacity of the excavator. In a mixture of earth and rock the best record time thus far has been about 24,000 cubic yards in 32 eight-hour shifts. Three men are required for the operation of the machine—one to control each of the boom engines and the third to run the rotating engine. Five other men are required to advance the track for the machine, and one man is placed in the canal prism to signal the operators. The machine is operated by compressed air received from a central plant with a pressure of 80 pounds to the square inch at the machine.

*Structures.*—Many methods of mixing and transporting concrete are in use. On several of the contracts the gravity Haines mixer is used, while on others various types of mechanical mixers are in operation. The concrete is transported and deposited generally in buckets running on narrow-gage cars or by boom derricks.

On Contract No. 11 the ingredients for concrete are raised to the top of a Haines mixer by means of belt conveyors, and the mixed concrete is conveyed from the mixer a maximum distance of 817 feet over a succession of belt conveyors. On arriving at the end of the belt conveyor, the concrete is placed in the forms by lateral belt conveyors or through pipes.

On barge canal masonry structures Portland cement concrete only is used. The proportions of the ingredients of the concrete are as follows:

First-class concrete—1 part cement, 2 parts sand, and 4 parts crushed stone.

Second-class concrete—1 part of Portland cement, 2½ parts of clean sand or crusher dust, and 5 parts of crushed stone or gravel.

Third-class concrete—1 part Portland cement, 3 parts clean sand or crusher dust, and 6 parts of crushed stone or gravel. All of the ingredients are measured in loose bulk.

The tests for tensile strength of Portland cement for a mixture of three parts by weight of crushed quartz and one part by weight of Portland cement are as follows:

At the end of seven days, at least 150 pounds per square inch; at the end of twenty-eight days, at least 240 pounds per square inch.

floors for the earlier designs and a special floor for the later designs. The special floor consists of hard maple strips about 1 inch thick by 2¾ inches or 3¾ inches wide (according to the thickness of the floor), dipped in asphalt of proper consistency and fastened together to form slabs by means of $\frac{5}{16}$-inch bolts. The slabs are spiked to wooden nailing strips on top of steel stringers. Where a good quality of maple is used, these floors give excellent satisfaction.

*Contract Prices.*—The following table shows the contract prices for the larger items of work under contract. This table shows rather large variations in prices bid for various classes of work. It should be remembered that the first contracts were let in 1905, and that bids have been received several times every year since that date. This covers at least one rather severe financial depression and two periods of increased cost of work.

CONTRACT PRICES.

| Contract | Excavation | | Embankment | Concrete | | | |
|---|---|---|---|---|---|---|---|
| | Nature | Price | | First | Second | Third | Wash Wall |
| 1 | Dry–Wet | .57¾ | .11½ | 7.75 | 6.75 | 5.85 | 1.90 |
| 2 | Dry | .40 | .12 | 6.50 | 5.50 | 4.50 | 1.50 |
| 2–E | .... | .54 | .15 | .0 | 6.25 | 0 | 2.00 |
| 3 | Dry | .41 | .12 | 6.65 | 6.15 | 5.25 | 1.50 |
| 4 | .... | .14 | .08½ | 0 | 5.20 | 0 | 2.12 |
| 5 | Dry–Wet | .12⅛ | .09½ | 0 | 5.65 | 5.25 | 2.35 |
| 6 | Dry | .46¼ | .15 | 0 | 5.25 | 4.90 | 0.80 |
| 8 | .... | .60 | .15 | 0 | 7.00 | 6.00 | 0 |
| 9 | .... | .50 | .17 | 0 | 6.75 | 6.25 | 2.50 |
| 10 | .... | .56 | .15 | 8.00 | 6.40 | 0 | 2.00 |
| 11 | Dry | .51 | 1st – .10 | 0 | 5.00 | •0 | 2.00 |
| | | | 2d.– .05 | 0 | 0 | 0 | 0 |
| 12 | Div. 1–Wet | 1.89 | .... | .. | .. | .. | .. |
| | Div. 2–Dry | .561 | .165 | 0 | 7.15 | 0 | 2.75 |
| | Div. 3–D. & W. | .308 | .... | 0 | 0 | 0 | 0 |
| | Div. 4–D. & W. | .187 | .... | 0 | 0 | 0 | 0 |
| 14 | Dry–Wet | .735 | 1st.– .17 | .. | .. | .. | .. |
| | | | 2d.– .11 | 8.00 | 7.50 | 6.50 | 2.50 |
| 15 | Dry–Wet | .285 | .175 | 0 | 6.00 | 0 | 2.25 |
| 17* | .... | .96 | .12 | 0 | 6.50 | 6.30 | 1.50 |
| 17 | .... | .96 | .12 | 0 | 6.50 | 6.30 | 1.50 |
| 18 | .... | .52 | .15 | 0 | 6.25 | 0 | 1.50 |
| 19 | .... | .60 | .... | .. | .. | .. | .. |
| | | .17½ | .14 | 0 | 8.40 | 0 | 1.35 |
| 20–A | Wet | .80 | .18 | 0 | 0 | 0 | 2.40 |
| 20–B | Wet | .638 | .18½ | 0 | 0 | 0 | 2.20 |
| 20–C | Wet | .51 | .18 | 0 | 0 | 0 | 0 |
| 20–D | Wet | .51 | .18 | 0 | 12.00 | 0 | 0 |
| 21 | .... | .48 | .15 | 0 | 7.00 | 0 | 1.75 |
| 23 | .... | .28 | .04 | 0 | 6.40 | 0 | 2.00 |

* Re-let.

But one unit price is paid for excavation, as there is no classification of the material excavated.

*Costs.*—The cost of excavation, as shown in cost data records, per cubic yard, including depreciation, interest, and overhead charges, has been as follows:

EARTH EXCAVATION.

| | | |
|---|---|---|
| By hydraulic dredge | from | $0.05 to $0.16 |
| By dipper dredge | " | 0.13 to 0.30 |
| By ladder dredge | " | 0.15 to 0.25 |
| By clamshell dredge | " | 0.09 to 0.15 |
| By revolving excavator and scraper bucket | " | 0.05 to 0.28 |
| By towers and scraper buckets | " | 0.11 to 0.30 |
| By steam shovel | " | 0.10 to 0.40 |
| By graders | " | 0.14 to 0.30 |
| By hand and team | " | 0.14 to 0.60 |

ROCK EXCAVATION.

| | | |
|---|---|---|
| Dry rock by steam shovel | from | $0.30 to $0.75 |
| Dry rock by hand and derrick | | $2.00 (average) |
| Wet rock | " | $1.00 to $2.25 |

Channeling has cost from 22 cents to 38 cents per square foot, depending on the character of the rock, the rock channeled having varied from soft, badly broken shale and slate to hard limestone.

The cost for second-class concrete has been from $4.20 to $7.00 per cubic yard in place, including depreciation, interest, and overhead charges.

*Organization and Direction of Work.*—The organization and direction of work is in the hands jointly of the Canal Board, the Advisory Board of Consulting Engineers, the Superintendent of Public Works, and the State Engineer. It appears that the duties and powers of the Canal Board are not defined in the Constitution, but are such as may be described by statute enacted by the legislature from time to time. The law requires that this Board pass upon practically all matters in connection with the canals, including the approval of plans and estimates connected with the construction work, and all alterations to existing contracts which increase the cost of the work. It has also been the custom of the State Engineer's department to submit to the Canal Board all other alterations and changes in plan.

The Canal Board is composed of the Lieutenant-Governor, Secretary of State, Comptroller, Treasurer, Attorney-General, State Engineer and Surveyor, and the Superintendent of Public Works.

The Advisory Board of Consulting Engineers, as provided for in

a thorough examination and check to be put on each act of the State Engineer by three independent persons or bodies, thus minimizing the number of mistakes which are likely to be inadvertently made, at the same time sacrificing something of celerity.

A feature which results in a certain loss of time and of efficiency is found in the frequent changes of administration. Five State Engineers have so far had charge of this work. The personnel of the Canal Board has been completely changed four times. The office of Superintendent of Public Works has been occupied by four men during the progress of the work. The only continuing body which has had authority over the construction since its inception is found in the Advisory Board of Consulting Engineers.

Appointments of the special deputy State Engineer and the three division engineers do not come under the civil service, and have generally changed with each new State Engineer. All resident and assistant engineers, levelers, rodmen, chainmen, and office help are appointed from civil-service lists made up from the results of competitive civil-service examinations.

*Progress of Work.*—On March 1, 1911, contracts had been let for work on the Erie, Oswego and Champlain Canals, estimated to cost $72,710,553, comprising about 95 per cent. of the total contracts for those canals. Work of a value of $26,831,432 had been completed on that date. Two contracts were let late in 1910, amounting to $1,806,177, on the Cayuga-Seneca Canal. On January 1, 1910, 41,674,000 cubic yards of excavation and 1,140,000 cubic yards of concrete had been completed, comprising 45 per cent. of the excavation and 60 per cent. of the concrete for the entire canal.

In January, 1909, a diagram was prepared based on the "past performances" and on estimates of the probable rate of progress after that date. This diagram indicated that the barge canal should be completed early in 1915.

Since January, 1909, the monthly progress has been plotted on the diagram, and shows that the work done exceeds the amount called for by the diagram.

On many large contracts the work up to date has been in the collection of plant, and the monthly rate in the future should be greater than in the past and the work should be completed by the date named.

The following table shows the value of the contract work completed during each year from January, 1906:

The State of Pennsylvania expended forty million dollars (and private capital largely supplemented this) in the construction of a canal and slack-water system aggregating 1100 miles in length which has gone out of use, with the exception of the stretches along the Delaware, Lehigh, and Schuylkill Rivers, on which an important traffic is maintained, and the slack-water navigation along the Monongahela River.

Whether the improvement of the waterways of this State will be again taken up is problematical, but in view of the possibilities of such improvement the Pennsylvania Water-supply Commission approves applications for the construction of dams or bridges across important streams, with a proviso that should the State or national government in the future establish improved waterways, the dams and bridges will be altered to meet the changed conditions.

The mechanical appliances illustrated, and the item of costs presented by Mr. Landreth, demonstrate the economies of modern construction methods, and the capacity of barges which the improved canal will pass (1500 tons) admit of applying improved means of loading and discharging; for one barge will carry the equivalent of a train-load of freight.

A producer of iron ores in large quantities informed me that it was expected that when the barge canal is completed the freight on iron ore from Lake Champlain to New York harbor will not exceed 50 cents, and the charge from Lake Erie to New York will approximate the same amount.

The advantage of railway service is that material or product can be loaded as large or small units on cars at mines or industries and delivered immediately at the works or manufactories where they are to be used, whereas in water transportation the freight must be conveyed from the locality where it originates to barge or vessel, and transferred from these to the consumer, requiring a breakage of bulk. Modern methods in dock construction, loading and unloading devices, materially reduce this expense, where the volume is sufficient to utilize these satisfactorily.

In this connection it may be interesting to note the fact that 140,000 tons of sugar from Hawaii were carried to Philadelphia in 1910, using the Tehuantepec Railroad across the Mexican isthmus, the modern facilities provided at the termini of this road permitting of breaking bulk at a material saving of over all water route.

The New York barge canal and modern propelling facilities for barges are confidently expected to advance greatly the business interests of that State, and to increase the traffic between the Lakes and the ocean.

latter-day conveniences, such as electric light, the telegraph, the telephone, and the railroad, people were wont to think of getting into the interior or of connecting one settlement with another by means of the watercourses—a perfectly natural means of transportation, and cheaper than overland connections. I was reading a few days ago about the state of affairs that confronted the people of western Pennsylvania at the time of the Whisky Insurrection, in 1794, when Washington was still President of the United States, and I found that those pioneers of Scotch-Irish ancestry were living upon fertile farms, and, being an industrious people, developed their resources and grew large crops of rye and other grain. Some of you may not know that Pennsylvania still grows more rye than any other State and is one of the greatest agricultural States in the Union, being perhaps fifth or sixth in rank in agricultural development. But those people were great raisers of rye, and it is recorded that they grew so much of it that they could not sell it; they fed it to their cattle and to their swine, and what was left over they turned into whisky, and out of the whisky they got money; the Government taxed the whisky, and that developed the Whisky Insurrection. Washington and all the officers of the Government were brought into that trouble, which, after it had resulted in the tarring and feathering of a great many collectors of revenue, finally led to relief measures under the law, which, after all, in most instances, is supreme. But these people, having only whisky upon which money could be raised, were obliged, because of their remoteness from industrial centers of population, to pay as much as five dollars a bushel for salt, and fifteen to twenty cents a pound for iron, or iron material for tools which came into the country, and they had to pay as much as five dollars for a hundred pounds of freight of any kind from Philadelphia. Such figures in this day would be regarded as extraordinary, and they were then. That was before the railroads.

There was no practical way of reaching that country by water, and the overland charges were too heavy to permit profitable business, consequently the people in the industrial centers along the coasts were driven to use the streams for purposes of transportation. One of the best instances I recall of the importance of the streams to the people was that which arose during the French and Indian War, when about the only fortifying done by the English was at Crown Point and Fort Ticonderoga on Lake George, with a view of stopping invasion by water. They knew they had little to fear by

of goods were laid upon railroad platforms, that complaints were rife as to delay in delivery, and that there were constant admissions on the part of the railroad men that capital could not be obtained to build sufficient equipment to keep up with the demand. This country was confronted with the fact that while it had been gridironed from one end to the other, and while it could have done a whole lot more business, erected more new factories, raised more produce on the farm, improved its waste lands, and raised greater crops, there was no use, as there was no way to get the products to market. The old means of transportation which our forefathers relied upon were no more.

Starting in the west, it was found, upon inquiry, that the people had been extremely active in obtaining Government appropriations, and, whereas they had little commerce in some instances, they had more aggressiveness than the people in the east; and it was found, too, that the western people were obtaining the bulk of the appropriations for the development of such streams as the Mississippi, and other streams where the commerce was insignificant compared with the streams of the east, which do an international trade.

It was about that time when Philadelphia began to believe that it had passed that stage where it should remain behind Baltimore and Boston in maritime importance, to say nothing of the great metropolis of New York, that an agitation was begun for an improved Delaware channel, 35 feet deep, so as to give Philadelphia a chance to exist in competition with its greater sister, New York. Philadelphia had once been a great maritime center, as it had been the capital of the nation. The Declaration of Independence and the Constitution of the United States, and the original laws, were framed here, and New York was not in the running. Philadelphia was the master of the situation. It had an outlet to New York and to Baltimore. When Pennsylvania built its railroad and got western connections, Philadelphia began to develop so rapidly that its rivals began to look on askance. New York saw the rich fields of the northwest and the traffic of the Great Lakes, and the richness of Canada along the United States border, and began to agitate for a canal connection with the great west. New York State had the natural configuration of ground to make the construction of a canal cheap, from the Lakes down the Mohawk Valley to the Hudson, and on the Hudson to the Atlantic Ocean, and while that State sought to have a canal constructed by the Federal Government, some of the other

as to their tracks, and scheduled as to the time of movements of engines and of trains. And we succeeded to a large extent in arousing public interest on this great question. Parenthetically, we succeeded in securing what had not been known in this neighborhood for twenty-five years—an authorization for a 35-foot channel in the Delaware River that shall enable Philadelphia to be placed on equal terms with Baltimore and Boston, and will place it only 5 feet behind the great city of New York.

One of the results of agitation is that we succeeded in the last Rivers and Harbors Bill in obtaining not only an authorization, but an appropriation sufficient to complete a 12-foot waterway in the Delaware from Philadelphia 40 miles north to the city of Trenton. As a result of the general agitation, this much has been accomplished for the city of Philadelphia, and it remains for those who are observant to say whether or not it was wise. We proceeded to urge the linking up, not only of the lower Delaware and the now to be improved upper Delaware, but of those waterways which course through other States along the line, and which, according to the commerce that bounds upon them, ought to be developed so that we can share in that commerce as we hope to do; to take advantage of those materials and those manufactures that we may be able to make and ship to other parts of the country at a cost at least commensurate with their value. In other words, it is a question of mutual exchange. First a matter of mutual appropriation and exchange, and then a matter of mutual help and mutual advancement.

There is a vast difference in freight rates as between the wagon-road and the railroad and the waterway. The most expensive, of course, is the wagon-road. Some statisticians say that it costs 25 cents per ton-mile to carry freight by wagon-road; 7 or 8 mills to carry it by railroad; 2 to 3 mills per ton-mile on the canal, and upon the ocean much less than that. The difference, however, is so marked as to lead sometimes to the thought that it is to the advantage of existing railroads not to permit canals to be constructed, because of the tendency to affect freight rates; but, on the other hand, from the viewpoint of the shipper, if he is to do more business and create opportunities for those who come after him, he ought to have the advantage of the competition, especially if he has only one method of transportation to carry his output.

A short time ago legislative work was so far advanced that it became necessary to procure figures and data to properly report to

now make. Of course, the saving would be tremendous if such a waterway could be devised, and since the Great Lakes are treacherous bodies of water, and life is frequently lost and much damage incurred there, it can be understood what a saving in life and property could be effected if the engineers could cut through this section of the country, which seems so favorably situated for it.

But to return to the Atlantic coastal project, the Belmont Company has taken over a project which has existed for two hundred years, and is now actually cutting a canal 8 miles long across Cape Cod. It is proposed to build a ship canal, 25 feet deep, that will save vessels making the passage outside at Martha's Vineyard and taking all the risk of the winds and the fogs which are so prevalent on that coast. That canal is now under way and much money is being spent upon it. It is known as the Belmont Canal; it is a private enterprise, and would, if constructed, charge toll. The gentlemen who are putting their money into it have taken it over with a view to making it a profitable undertaking. That is not a part of the project we are advocating along the coast, although we are in entire sympathy with it.

There have been no less than a thousand wrecks around Cape Cod during the last twenty-five years, and five hundred lives have been lost in that time. As much as fifty million tons of commerce pass Point Judith every year.

Statistics compiled by the Traffic Committee of the Atlantic Association, and supported by the statistics of the Life Saving Service of the United States, show that along the Atlantic coast there have been no less than 5,700 wrecks during the last ten years, involving a property loss in vessels and cargo of forty millions of dollars and a loss of 2,200 lives. We want to save some of that property loss; we want to save some of that cargo; we want to save some of those lives; and we want to save some of the time and the risk in that outside sailing, by letting vessels that do not want to go outside do an inside business.

The engineers of the United States, acting under the authorization of 1909, have found a safe route from Boston inside of Cape Cod; one by way of Plymouth Harbor south, and the other by way of Hingham Bay. Either of these canals would traverse fertile territory, would connect large cities that are inland, and would reach great manufacturing centers, points where large quantities of shoes and textiles are made and shipped, and which, to a large extent, are now

million dollars; that is, about twelve million dollars more for a waterway through the most productive manufacturing district in the country—twelve million dollars more than President Taft, along with Congress, has approved to be spent upon the Ohio River to obtain a 9-foot depth from Pittsburg to Cairo. When I said to you in the beginning of this talk that I thought I could show you there had been a neglect of the streams along the Atlantic seaboard, I meant exactly what I said. There is more tonnage in this little link behind Staten Island, over a length of 16 miles, more commerce—four times over—than upon the whole of the Mississippi and all its tributaries thrown in, with the single exception of the Ohio River. And below the city of Philadelphia there is seven times the commerce there is on the Mississippi, leaving out the Ohio, which derives most of its business from western Pennsylvania. And yet upon the Mississippi there has already been spent upward of two hundred millions of dollars, and what has been accomplished? Every one knows what has been accomplished, or rather what has not. Compare this with the twelve or thirteen million dollars spent upon the Delaware; we are to get ten million dollars for a 35-foot channel in the Delaware, compared with two hundred millions for the Mississippi to obtain a depth of 6 feet on the upper reaches and 9 feet on the lower reaches. Think of it! So I say to you we have been neglecting the streams on the Atlantic seaboard, and when we propose a project that will save forty millions of dollars and save thousands of lives, we want the support of men like you. Think of two hundred million dollars spent on a project like that of the west, when these lives and this commerce could have been saved if the eastern people had only been more wide-awake. If we have not done this, then I say we have been neglecting our opportunities, and you as engineers have not been doing the work that ought to have been done by you and men of your class.

In opening up these canals, the argument is that we would not only bring cities together and lead them into an interchange of their commerce, and do a straight business with each other, and find greater outlet for their goods, but we would also build up communities along the coast; and if we were to open up a suitable canal from Philadelphia to New York, and make it free, and take it away from private control and the ban of tolls, industries would grow up along the line of that canal, and those industries would thrive, and New York and Philadelphia would be effectively linked together. It is not a

We ought to take over that canal, rebuild it, or build a new one, and the cost would not be more than eleven or twelve million dollars at the outside. It is said that between Philadelphia and Baltimore the amount of tonnage that takes to the water is somewhere between fifty and seventy-five million tons. Twelve million dollars would build a canal that would save that tonnage all outside risk.

The entrance to the Chesapeake and Delaware Canal has a depth of 9 feet of water. New York State is constructing a 12-foot barge canal, and is going to pay one hundred and one million dollars for it, which is more than is needed for the entire waterway from Boston to Key West.

The project continues from the lower Chesapeake south from Norfolk. There are two canals now between Norfolk and the two Carolina sounds. The Dismal Swamp Canal is one of great historic interest. Washington himself surveyed this country, and was very much interested in the canal. He found that Lake Drummond was a stream fed not only from some mysterious source, but so perpetually fed that it would be of great benefit to these great bodies of water in North Carolina. These two sounds, the Albemarle and the Pamlico, the one fresh and the other brackish, are the two largest bodies of fresh and brackish water in the United States, outside of the Great Lakes, and have 2500 miles of navigable waterways feeding them. The entire coastal country here is very largely in the primeval state that it was in the days of Washington. The construction of canals would undoubtedly help this part of the country. Much of this useless land would be drained by the canals and made useful; this country would grow, when relieved of the overplus of water and marsh which frequently prevails. At the lower end of Pamlico Sound is an entrance to the ocean.

I want to call your attention, however, to Cape Hatteras, which is regarded by many as the most dangerous point along the coast, to the mariner. The strips of beach here protect the mainland, and these inland waterways which it is proposed to develop are much like those which New Jersey has begun to develop.

The Chesapeake and Albemarle Canals are both toll canals, and during the last nine months of 1910 they carried more than 7200 vessels of one kind or another from points south to the north, and from Norfolk, south.

Congressman Small some years ago tried to have a channel cut through the lower end of Pamlico Sound to enable vessels to get to

facturer is, he nevertheless is dependent upon him for certain articles of machinery and certain improvements; in the invention of modern machinery for the saving of labor, and many other things, just as the Government is dependent upon him for great constructive works that are to be done in the name of the Government.

I would like to see a little more of the practical engineer in our United States life, for the engineer is a creative force, and our national life would be benefited in every way by his activity.

Considering the congestion in large cities and the tendency to overdo the professions, I have wondered whether it would not be well for this country to encourage more construction learning, rather than the literary, or the purely artistic, or many other branches which may not be so important after all; would it not be better to encourage the useful rather than the ambitious side of life? In other words, it seems to me that if the Government is to raise the money from the agriculturalist and the worker, and if the Government is competent to spend the money thus acquired, it should also consider the social welfare of its people by spending a little money encouraging the practice of constructive work through the youth of the country. It would thus be making two blades of grass grow where one grew before.

All over the west we find greater activity than we do here in the east; more aggressiveness than here. The western man has had to hew his way through the wilderness, and the western dweller is becoming more and more, day by day, the competitor of the east and a bidder for the industrials of the east. He comes in for appropriations, and he gets them. He applies them to industries and manufactures. Indeed, he is forging ahead. A short time ago Boston thought it was the greatest center of the shoe industry in the United States, but the last census showed that not only had St. Louis exceeded Boston in population, but it had also become, way out there on the Mississippi, in the interior of the country, the first and greatest shoe manufacturing city of the United States. But the western man is moving, and on the hustle, and in Seattle, with perhaps only one-fourth or one-fifth the population of Philadelphia, they have seven or eight lines of railroad coming and going, and all the capital incident to construction for use in that community, while Boston jogs along with one railroad system and is entirely satisfied that it is moving along with the rest of the world.

In Philadelphia, with one of the most magnificent rivers of this

# ABSTRACT OF MINUTES OF THE CLUB.

Business Meeting, April 1, 1911.—The meeting was called to order by President Christie at 8.30 P. M., with 116 members and visitors in attendance. The minutes of the Regular Meeting of March 18th were approved as printed in abstract. The amendments to the By-Laws, relative to the status of the Junior Section, proposed at the meeting of the Club on March 4th, were brought up, and, after discussion, were approved for letter ballot.

Following a report of the Tellers, the President declared the following elected to membership: Active, George A. Baker, Alfred D. Morris, John Wallace Thompson, Charles D. Watson; Junior, Charles Emil Hubsch, John Allen Remon, Victor Shuman.

Mr. J. Hampton Moore, visitor, presented the paper of the evening, entitled, "The Atlantic Coastal Project," which was discussed by Col. J. C. Sanford, A. B. Burke, John C. Trautwine, Jr., James Christie, and others. On motion of Mr. Swaab, the thanks of the Club were extended to Mr. Moore for his interesting paper.

Business Meeting, April 15, 1911.—The meeting was called to order by President Christie at 8.30 P. M., with 72 members and visitors in attendance. The minutes of the Business Meeting of April 1st were approved as printed in abstract.

The Tellers of election presented the following report of votes cast on the amendments to the By-Laws affecting the Junior Section: For the amendment, 63; against the amendment, 0. The President, in accordance with this report, declared the By-Laws so amended.

Mr. William B. Landreth, visitor, presented the paper of the evening, entitled, "The New York State Barge Canal," which was discussed by James Christie, John Birkinbine, and John C. Trautwine, Jr.

Business Meeting, May 6, 1911.—The meeting was called to order by President Christie at 8.30 P. M., with 112 members and visitors in attendance. The minutes of the Business Meeting of April 15th were approved as printed in abstract.

A Committee of the Board, formed to draft a resolution on Building Laws in this State, presented its report, on which it was desired to obtain the sense of the meeting; but, after discussion, it was ordered that the matter be laid upon the table.

Following a report of the Tellers, the President declared the following elected to membership: Associate, Charles J. Corr; Junior, Francis X. Kern, Jr., Henry P. Kirchner, and James Logan.

Mr. Frederick W. Taylor, visitor, presented the paper of the evening, entitled "The Principles of Scientific Management," which was discussed by John C. Parker, H. M. Chance, E. M. Nichols and other members and visitors. President Christie expressed to Mr. Taylor the thanks of the Club for his most interesting paper.

# ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS.

Regular Meeting, April 13, 1911.—Present: President Christie, Vice-Presidents Hess, Hewitt, and Plack, Directors Hutchinson, Swaab, Halstead, Worley, Cooke, Develin, Gilpin, Vogleson, the Secretary, and the Treasurer. The minutes of the Regular Meeting of March 16th were read and approved..

The Secretary presented the monthly statement of the financial condition of the Club, which showed a net gain for three months of $312.19.

After a discussion of delinquent accounts, it was ordered that for house charges of less than $1.00, a member's credit should not be stopped, nor should his name be posted on the bulletin board.

The death of Mr. Heber S. Thompson, which occurred on March 9, 1911, was announced.

Following the reading of a letter from the Philadelphia Chapter of the American Institute of Architects, it was ordered that a letter be written to His Honor, the Mayor, indicating the indorsement of the Engineers' Club of the development of a comprehensive city plan, and recommending the appointment of a permanent commission on city planning.

Following a letter read from the President of State College, it was ordered that the President appoint a delegate from this Club to serve as elector at the State College Annual Meeting.

On motion, it was ordered that the House Committee be authorized to make arrangements for a visit to the Engineers' Club of Brooklyn, provided the same be done without expense to the Club.

Following the reading of a report from the Committee on Standardization of Engineering Elements, it was ordered that this Committee be made a permanent Committee of the Board of Directors, and that it be authorized to appoint the two sub-committees recommended in its report.

For the guidance of the House Committee, it was moved that the sense of the Board was that the rent of the meeting-room for outside organizations be fixed until September 1, 1911, at $10.00, with an additional charge of $3.00 for the use of the lantern.

Regular Meeting, May 18, 1911.—President: President Christie, Vice-Presidents Hess and Plack, Directors Hutchinson, Mebus, Swaab, Halstead, Worley, Develin, Gilpin, Vogleson, the Secretary, and the Treasurer. The minutes of the Regular Meeting of April 13th were read and approved.

The Secretary presented the monthly statement of the financial condition of the Club, which showed a net gain for four months of $555.44.

The letter to the Mayor of Philadelphia, indicating the indorsement of the Engineers' Club of Philadelphia on the development of a comprehensive city plan, ordered to be sent at the last meeting of the Board, was read.

It was ordered that the $850.00 appropriated as a sinking fund for retiring

to consider the question of smoking in the meeting-room: Henry Hess (Chairman), F. K. Worley, W. P. Taylor, Richard Gilpin, and W. L. Plack.

It was announced that the following had accepted service on the Committee on Nominations for the current year: Wm. Easby, Jr. (Chairman), H. H. Quimby, J. C. Wagner, W. B. Riegner, Herbert Rice, H. E. Ehlers, and Wm. C. Kerr.

The meeting adjourned, upon motion, at 9.30 P. M., to continue on call of the chair.

# PROCEEDINGS

OF

# THE ENGINEERS' CLUB

OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.




Vol. XXVIII. OCTOBER, 1911. No. 4

PAPER No. 1101.

## NOTES ON THE DESIGN OF IMPELLERS OF MODERN CENTRIFUGAL PUMPS.

N. W. AKIMOFF.

(Active Member.)

*Read March 4, 1911.*

THE impeller shown in Fig. 1 is characteristic of an ordinary centrifugal pump for high lifts and moderate capacities. In such pumps the ratio D : d is considerable, about 2 : 1 to 3 : 1, and the layout of the vanes of such an impeller does not present any special difficulties.

Fig. 2 shows a typical low-lift impeller; the ratio of the outside diameter to the diameter of inlet is here reduced to a minimum; this may be due to the low head required or else to a high rotative speed.

The layout of the vanes of such an impeller is a problem of a rather special nature, and admits, by proper treatment, of a definite solution. To undercut the inlet tips of the vanes as shown by *a* would result in too short a vane (radially). To shape the inlet tips as shown in *b* and *c* would mean nothing at all, and only the poorest result can be expected from such an arbitrary outline. The correct shape is *d*, and the object of this paper is precisely the layout of this curve—the *entrance curve;* also of the inlet tips of the vanes thereby outlined.

The side view of such an impeller is given in Fig. 3, where two blades are shown; such blades are necessarily of the doubly curved kind, unlike the blades of Fig. 1, which are of cylindrical nature.

Before taking up the layout of the blades proper it will be necessary to look into the nature of the flow of water into the impeller (or, rather, through the impeller). This problem has been treated by Dr. Prasil in his "Mouvement des liquides dans les corps creux de Révolution" (Grenoble, 1908).

His method is as follows: A jet of water impinging on a plane can be treated mathematically by applying the general equations of hydrodynamics. We first assume that the movement is of a

FIG. 1.

FIG. 2.

steady, non-vortex nature; we further simplify the general equations by using cylindrical coördinates, $z$, $r$, and the general equation thus obtained becomes

$$\frac{\delta^2 F}{\delta z^2}+\frac{1}{r}\frac{\delta F}{\delta r}+\frac{\delta^2 F}{\delta r^2}=O\ldots(1)$$

where $\delta$ denotes partial differentiation, $z$ and $r$ are axes shown in Fig.

4, and $F$ is the *velocity-potential, i. e.*, a function whose derivative as to $z$ is the velocity along $z$, and whose derivative as to $r$ gives the velocity along $r$.

One of the integrals satisfying equation 1 is

$$F=2kz^2-kr^2 \,..\,(2)$$

where $k$ is a constant. It is easy enough to see that

$$\frac{\delta^2 F}{\delta z^2}=4k;\ \frac{\delta F}{\delta r}=-2kr \text{ and } \frac{\delta^2 F}{\delta r^2}=-2k;\ \text{whence } 4k-2k-2k=o$$

so that $F$ (equation 2) is a solution of equation 1.

The equation

$$F=const. \,..\,(3)$$

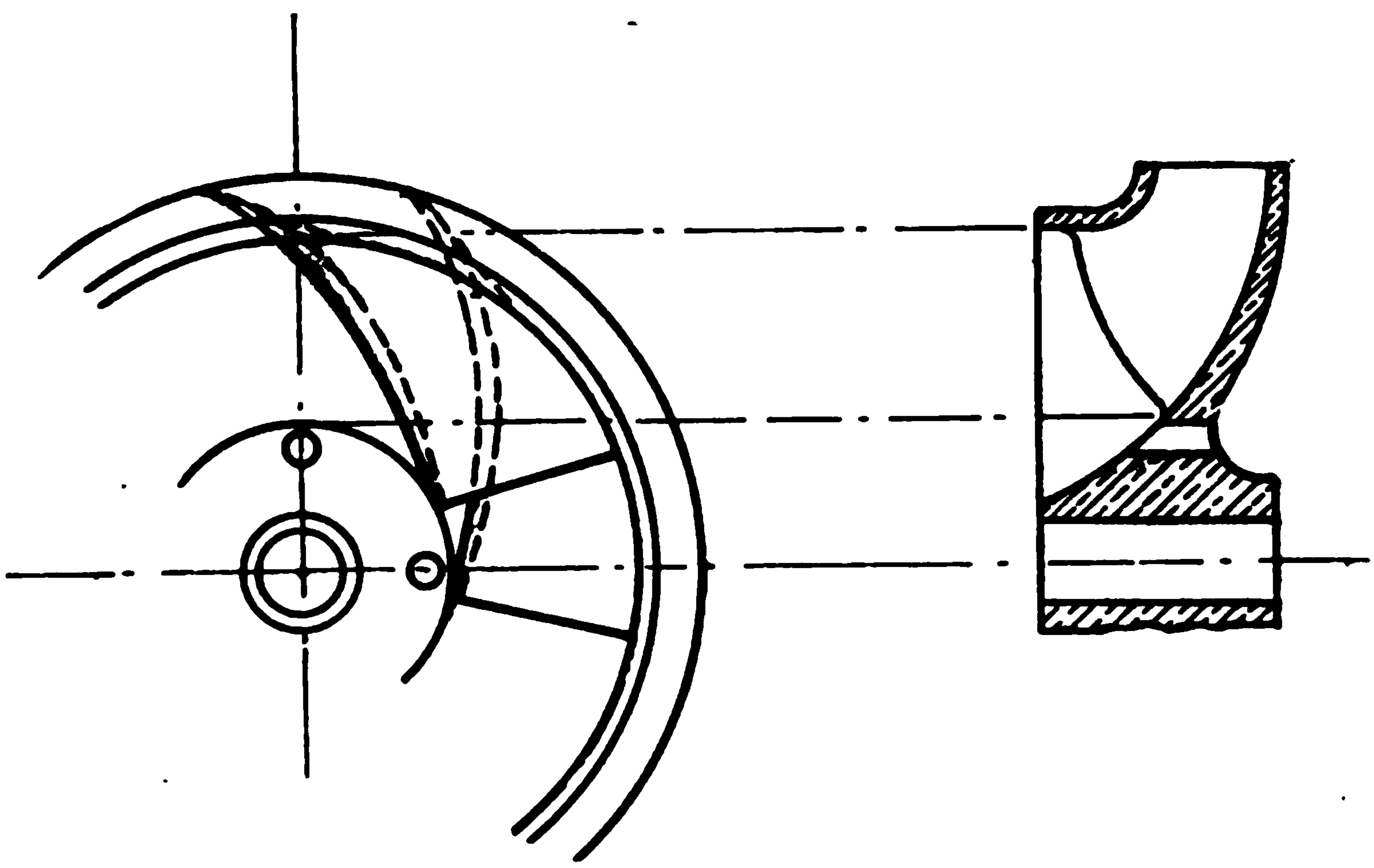


FIG. 3.

gives the curves of constant velocity-potential; this equation can be reduced to the well-known form

$$\frac{z^2}{a^2}-\frac{r^2}{b^2}=1;\ \text{where } a=\sqrt{\frac{c}{2k}} \text{ and } b=\sqrt{\frac{c}{k}}\ \ (c \text{ being the constant from (3)})$$

This is an equation of a family of hyperbolæ the asymptote of which forms with the $z$ axis an angle whose tangent $= \frac{b}{a} = \sqrt{2}$, so that the angle is 54° 44′.

The velocity along $z$ is

$$w=\frac{\delta F}{\delta z}=4kz \,..\,(4)$$

and the velocity along $r$ is

$$v=\frac{\delta F}{\delta r}=-2kr\,..(5)$$

so that $w$ is independent of $r$ and $v$ is independent of $z$ (and this is precisely the reason why (2) is the solution of our problem). The total velocity of each particle of water is then

$$c^2=w^2+v^2=16k^2\,z^2+4k^2\,r^2\,..(6),$$


Fig. 4.

which is an equation of an ellipse whose axes are 2 : 1, and whose smaller axis is along $z$; the equation of the stream lines will be, of course,

$$\frac{dr}{\frac{\delta F}{\delta r}}=\frac{dz}{\frac{\delta F}{\delta z}};\ \text{so that}\ \frac{dr}{-2kr}=\frac{dz}{4kz}$$

integration gives $S=r^2 z=\text{const.}$ (See Tait, "Dynamics," p. 323, or Forsyth, "Diff. Eqns.," p. 131, on Trajectories.) These are curves of third degree, having the axes $z$ and $r$ for asymptotes. Fig. 4 also shows $c$ lines (of equal total velocity) as well as $F$ lines (equal velocity-potential) and $S$ lines (stream lines or lines of flow). This layout was made for the following data: $w_e$ at top $=10$ ft. per second; $w_s$ at bottom $=3$ ft. per second. The total length of sleeve $z_e—z_s=10$ ft. Discharge per second $=150$ cu. ft.

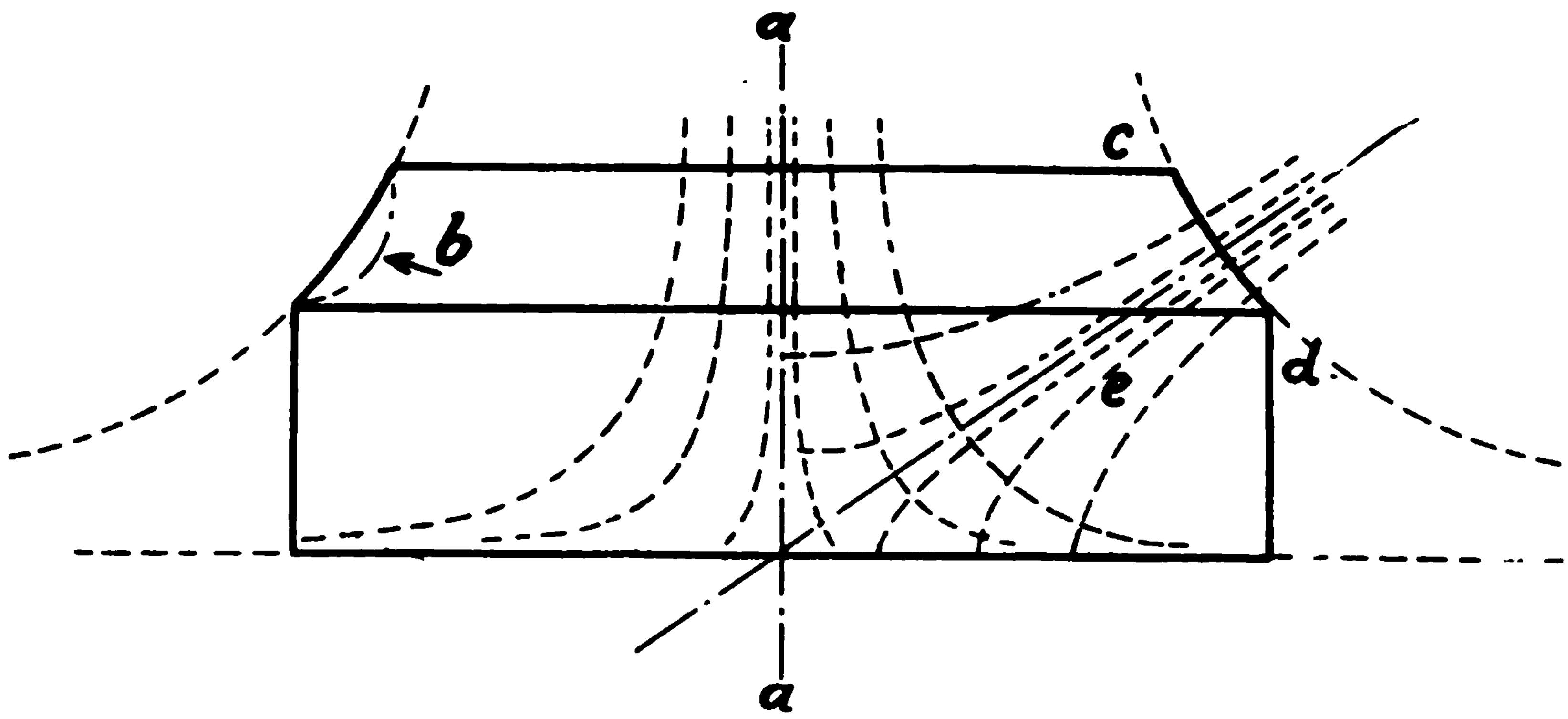



FIG. 5.

In order to determine $F$ we first find $k$ as follows: From (4) we have $w_e = 4kz_e$ and $w_s = 4kz_s$, so that $w_e—w_s = 4k\ (z_e—z_s)$; now, $w_e = —10$ and $w_s = —3$ (the sign — shows flow *toward* the origin); or $—10—(—3) = 40k$; hence $k=—\frac{7}{40}$, so that from (2)

$$F=\frac{7}{20}\ z^2+\frac{7}{40}\ r^2 \text{ and } w=-\frac{7}{10}\ z \text{ and } v=\frac{7}{20}\ r, \text{ whence } c^2=\frac{49}{100}\ z^2+\frac{49}{400}\ r^2.$$

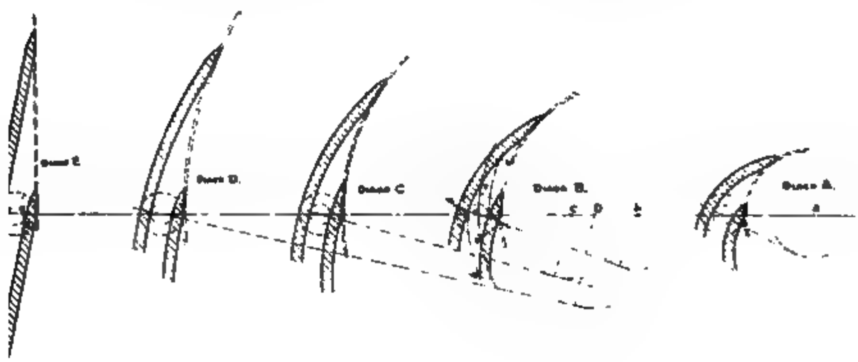
$F$ and $c$ lines can easily be plotted by assigning various values for $F$ and $c$ and determining $z$ and $r$ from corresponding equations.

$$\text{From } w_e=-\frac{7}{10}\ z_e \text{ we have } z_e=-\frac{10}{7}\ w_e=\frac{100}{7}=14\tfrac{2}{7}$$

Knowing the amount of water handled per second, we have $r_e=2.19$ ft., so that the outer stream line will be given by the equation $S=r^2 z=68.5$; other lines of flow will be found by assigning smaller values for $S$.

It is a most helpful exercise indeed to work out a few examples for some known conditions. Fig. 5 represents a similar layout for a

different set of conditions, roughly approaching an outline of a single suction impeller of a centrifugal pump. From it we may observe the following: For a free, non-constrained flow the entrance, *c*, cannot be quite parallel to the shaft; neither can the discharge, *d*, be exactly at right angles to the shaft. The entrance curve, in order to be ⊥ to the stream lines, must be of some such shape as *e*.



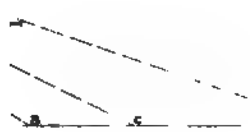


Fig. 6

Fig. 7

In practice, however, we deliberately depart from these conditions in some such manner as shown at *b*, and, by so doing, alter the velocities of outer streams. It can be shown that for such conditions of flow the velocity will be inversely proportional to the radius of curvature of each stream. In working out an actual impeller layout it is of great importance to know what the theoretic stream lines would be

and how far we depart from them, so that new stream lines can approximately be drawn corresponding to the distorted shape of the profile.

The actual layout is done in the following manner: Being given the capacity, the total head and the speed of the pump, we first determine the diameter and the width of the impeller, using existing theories and practical data. (See our article in the "Journal of the Franklin Institute," May, 1911.) We now draw the stream lines (Fig. 6), such as 1–*A*, 2–*B*, 3–*C*, and 4–*D*. The entrance line is then laid out subject to two conditions: (*a*) It is at right angles to each stream line at intersection; (*b*) its *length* is such that it will admit water into the impeller at the same velocity as the velocity of suction. This suction velocity, prescribed beforehand, is constant, while the peripheral velocity is, of course, proportional to the radius, so that the triangle of velocities for *d* will be quite different from that for *a*. The next step is then to determine the vane angles corresponding to various points of the entrance curve, such as *a*, *d*, etc., using the ordinary rule of resolving the absolute velocity into its two components—peripheral and relative. The entrance elements of the blade are supposed to be drawn upon corresponding *cones*, whose vertices will be at *A*, *B*, *C*, and *D* respectively. These cones we now develop upon a plane as shown in the diagrams in the upper part of the drawing. The diagram *E* belongs to the point *E* of the entrance curve. In this particular case we have a portion of a cylinder to be developed instead of that of a cone, and the corresponding elements of the blade will be straight lines instead of being curved, as is the case for all other points of the entrance line as shown in diagrams *A*, *B*, *C*, and *D*. (Involutes are recommended for the inlet elements of the blades. It is easy enough to draw an involute, bearing in mind that $d = D \sin \alpha$, where $d$ is the diameter of the generating circle, $D$ is the diameter of inlet, and $\alpha$ the angle of inlet at the corresponding diameter, $D$.)

We now wrap the diagrams upon corresponding cones and draw the plan view of the blades as shown in Fig. 7. So far as the discharge elements of the blades are concerned, it may be mentioned that the discharge angles are chosen according to general practice and to the fancy of the designer. Our immediate task is properly to transfer the diagrams and thereby to determine the suction elements of the vanes. On the plan view, Fig. 7, we draw circles with radii, such as, for instance, *Oa* (for diagram *B*), and transfer various points from

diagram *B* upon Fig. 7, so that, for instance, *a–a* (diagram *B*) = *a–a* (Fig. 7). For each diagram we need only three points and three circles, such as *Oa*, *Ob*, and *Oc*.

In this manner we have obtained the suction tips of the blades; connecting them to the discharge tips is a matter of judgment and can be done in several ways. The next step is to lay out the lines of intersection of the blade surfaces with planes $\perp$ to the shaft (such as 1–1, 2–2, etc., see Fig. 6). Radial lines are drawn, such as 0–5, 0–6, etc. (Fig. 7), using the diagram *E* for determining its angular distance from the center line.

The intersection of 0–6 with such lines as 1, 2, 3, etc. (Fig. 7), gives us the curve 6–*VI* (Fig. 6); for instance, the intersection of 0–6 and the line 2 (Fig. 7) is *Z*, and the distance 0–*Z* (Fig. 7) gives the corresponding point *Z* in Fig. 6, thus forming the line 6–*VI* (Fig. 6).

Having obtained lines similar to 6–*VI* (Fig. 6) we plot their intersections with 1–1, 2–2, 3–3, etc. (Fig. 6). For instance, the line 6–*VI* (Fig. 7) is formed as follows: Upon the radial line 0–6 (Fig. 7) we lay out the distance 6–6 (Fig. 6); again, upon the radials 0–7 and 0–8 we mark the intersection of 6–6 with the lines 7–*VII* and 8–*VIII* (Fig. 6), and the line 6–*VI* (Fig. 7) is the section of the blade with the transverse plane 6–6 (Fig. 6).

PAPER NO. 1102.

# SOME ENGINEERING FEATURES OF ELECTRIC FURNACES.

CARL HERING.

(Active Member.)

*Read March 4, 1911.*

As it is such a simple matter to convert electric energy into heat, electric furnaces have to a large extent been designed and constructed by metallurgists and chemists rather than by engineers; almost any crude electric contrivance will produce heat, and hence was good enough; the main question was: Will it perform the necessary metallurgical, physical, or chemical reactions? Now that the latter has been demonstrated beyond question for a large variety of processes, the inevitable question naturally arises, "Will it pay" to use electric heat? To determine this it becomes necessary to design and construct the furnaces so that they will have the highest possible heat efficiency; that is, to reduce the inevitable heat losses to the least possible. This is of far greater importance for electric furnaces than for those using the combustion of fuel, as the cost of a unit of heat is generally considerably greater when produced electrically than when generated directly by combustion. Fuel furnaces are, as a rule, so very wasteful that their design is of little or no aid in designing electric furnaces. The important problem of to-day, therefore, in connection wih electric furnaces, is that of their design and construction so as to make them as perfect an engineering structure as possible, hence it falls into the province of the engineer as distinguished from the chemist or metallurgist.

The purpose of this present paper is to point out and discuss briefly some of these engineering features which are involved in the design and construction of electric furnaces, with a view to perfecting them as engineering structures.

Before doing so, however, it may be well to dispel the prevalent idea that the electric furnace is still only a laboratory device or a mere fad. It is true that it is not as commonly seen as many other

diagram *B* upon Fig … an enclosed structure, the
(Fig. 7). For each … appreciated by the layman,
circles, such as *Oa*, … ends of large furnaces in daily
In this manner … successful use commercially for
connecting them … thousands of tons of products
can be done in … known products cheaper or better
intersection of … products are made which were
2–2, etc., see … not be produced commercially
(Fig. 7), using … former may be mentioned aluminum,
the center … carbon, phosphorus, etc.; among the
The int… … carbid, artificial graphite, silicon, siloxi-
us the … … gen, etc.
the line … developed by the electric furnace even
spond… … of nations. Sweden, for instance, was
Hav… … owing to the greatly increased cost of
secti… … large available water-powers, the electric
(Fig. … less charcoal than the blast furnace does.
la… … great national industry again for that country.
… western coast of Norway, apparently useless for
… fair to develop wealth-producing industries
… due to the electric furnace operated by the
… water-powers on the seacoast, where trans-
… restricted by railroad monopolies. Canada
… are other districts which will be enriched by the
… as a connecting-link between the mineral re-
… water-powers.

… seventy to eighty electric arc furnaces in operation
… refining steel, mostly in France and Germany; in
… and California there are several for the reduction
… induction furnaces for steel refining, there are said to
… and forty in operation or building, mostly in Ger-
… 17 tons of artificial graphite, which in many respects
… the natural product, are produced daily in the electric
… about 6 tons of bisulphid of carbon, and all of the
…

… early history of our earth it was a seething mass of liquid and
… exceedingly high temperatures, at which most chemical affini-
… to exist; hence the elements were mostly free and uncom-
… As it cooled, the chemical forces which cause these elements

tricity is practically instantaneous. It is also like a flow of water through a porous material.

Quantitatively, the flow in heat units per second is directly proportional to that which causes it, namely, the difference of temperature; and inversely to that which opposes it, namely, the thermal resistance of the body, which is the reciprocal of what is generally termed the conductivity (more correctly, the conductance) of the body. Hence the quantitative law is exactly like the law of Ohm, which is the fundamental law of electric flow. And if the units are properly chosen, the coefficient also becomes unity, as it is in Ohm's law, hence the flow is then numerically equal to the difference of temperature divided by the resistance; the formula for its calculation therefore may be reduced to the simplest and most elementary kind.*

The study of such flows of heat through bodies does not seem to have been given the attention which it deserves; it applies also to other branches of engineering, such as refrigeration, the heat insulation of engine cylinders and steam-pipes, the transmission of heat from the hot gases in a boiler to the water, the construction of thermos bottles, etc. A postage-stamp pasted on the fire side of a steam-boiler tube will not even be charred by the flames, showing the existence of an enormous resistance to heat flow on the outside of the tube; a study of the phenomenon of the flow of heat showed how this resistance can be diminished, resulting in a much greater flow, hence increased steaming capacity. An excessive heat insulation of a gas-engine cylinder would result in its destruction. The over-insulation of steam-pipes, which is said to be quite common practice in this country, results in the waste of more money for the covering than the saving of steam warrants. All such engineering problems would be simplified by giving this subject of the flow of heat more attention. The lack of proper units and physical constants for such calculations is doubtless responsible in part for the neglect of due consideration of this branch of engineering.

Before discussing some of the applications of the laws of the flow of heat to the design and construction of electric furnaces, let us summarize briefly the general features of the furnaces themselves.

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* See "Thermal Resistance and Conductance; the Thermal Ohm and Thermal Mho," by Carl Hering (Metallurgical and Chemical Engineering, January, 1911, vol. ix, p. 13).

In general, there are two classes—resistance and arc furnaces. In the former the heat is generated in the interior of a conductor, due to the resistance offered by the material to the passage of a current through it. The ordinary incandescent electric lamp is a simple illustration of the generation of heat in this way. In the arc furnaces the heat is generated by the passage of a current through a gap formed between the ends of two conductors; the bridging of this gap by the current is called the electric arc. The ordinary arc lamp used in streets and halls is a simple illustration of the generation of heat in this way.

The general characteristics of these two classes of furnaces are as follows. In the resistance furnace the current may be passed through the material itself which is to be treated, or it may be passed through a permanent near-by conductor, and transmitted to the material to be treated by radiation, conduction, and convection.

When the heat is generated in the material itself, the heating becomes very efficient, practically 100 per cent., as all the heat is generated in the body itself, where it is wanted. This is therefore the most efficient method; it is also generally the most rapid, as no time is lost for the heat to penetrate by the slow process of conduction, from the outside to the inside; it is all in the inside when it is generated, and it can be generated very fast by simply increasing the current. Hence in some respects it is the ideal method. As long as the material remains solid, there is apparently no limit to the temperature which may be reached, for by continuing the passage of the current, heat continues to be generated, and if it cannot escape, it accumulates, thereby continually raising the temperature until the losses equal the input. This is the case in the graphite and carborundum furnaces, in which exceedingly high temperatures are obtained, estimated to be from 2300° C. to 4000° C. (4000° F. to 7500° F.).

If, however, the material through which the current passes becomes liquid, generally in an open channel, there is a very decided and sometimes very serious limit to the temperature which can be produced, for when the current reaches a certain value, dependent on the cross-section and the density of the material, a formerly unrecognized force comes into play, which contracts the column of liquid until it is severed completely, and this, of course, interrupts the current. This peculiar phenomenon was encountered, studied, and described by the writer some years ago, and termed by him the "pinch phenomenon," by which name it is now generally known here and

abroad. By submerging these channels of liquid deeply below the surface, the writer found that this pinching force may not only be prevented from interrupting the circuit, but may even be used to cause the liquid in the confined channel to flow out of it as quickly as it is heated, whereby it also produces much desired circulation.* Such a furnace, then, has the desirable qualities of one with solid resisters, besides some new qualities due to the rapid circulation of the heated liquid.

The electrodes of such furnaces, which conduct the current from the outside of the furnace to the inside, are one of the most important elements, as also one of the most troublesome. To dispense with them, therefore, seemed a great improvement. This is accomplished in the induction furnace, and is its chief advantage; in such furnaces the current which does the heating is generated by induction in the metal in a trough, forming a complete circuit through which the current can circulate; hence it requires no direct connections with outside circuits. It therefore has some advantages over furnaces which require electrodes. Among its disadvantages are: its complicated construction and greater cost; the difficulty of preventing excessive losses of heat because the heated material necessarily exposes a very large surface to such losses; its low power factor, which means larger and more expensive electric machinery, especially so for the larger furnaces, etc.

The characteristics of the arc furnaces are briefly as follows: The temperature of the arc is always that of the volatilization of the material of the electrodes between which the arc plays, and as these are generally carbon or graphite which have extremely high vaporization temperatures, it follows that the temperatures developed in such arc furnaces are exceedingly high—generally far above what is required. This heat is, however, all generated in the arc itself, and at the surfaces between which the arc plays; hence it can reach the main body of the material to be treated only by radiation, conduction, and convection, and this necessarily takes time; the exceedingly high arc temperature aids this. In heating liquids with an arc, much of the energy must necessarily radiate upward, hence is not utilized, and even tends to destroy the roof of the furnace. Moreover, heating a

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* See "A New Type of Furnace," Trans. Amer. Electrochem. Soc., vol. xix, 1911, p. 255; also "Electric Furnaces," Journal of the Franklin Institute, vol. clxii, July, 1911, p. 55.

liquid from the top surface is not the most rational way, as the heat travels downward with difficulty and quite slowly, hence it takes time for the heat to penetrate; this is also the case in open-hearth furnaces. The electrodes in arc furnaces are consumed, and therefore require continuous feeding, or else the arc goes out. Some and perhaps considerable of the electric energy for such furnaces is necessarily consumed in volatilizing the electrode material, although part of this may be again recovered.

In many of the chemical reactions which it is intended to have take place in furnace processes, more particularly in those conducted in electric furnaces, energy is consumed by being stored up in the product formed, just as energy is stored in compressing air in tanks. In the formation of calcium carbid, for instance, in the electric furnaces at Niagara Falls, part of the energy of the falls is stored as chemical energy in this material, and it can be set free again later as desired, as light or heat. An electric furnace must therefore also supply this energy, besides merely generating the heat required for the reaction to take place. Sometimes—as in the reduction of aluminum, for instance—this stored energy becomes very great.

Some of the chief differences in the characteristics of combustion furnaces and those operated by electric energy are best shown by the curves in Fig. 1. Let the vertical distances represent temperatures, and the horizontal ones the costs of heating a given quantity of a material to those temperatures. The curve for the combustion furnace will be seen to rise quickly at first, showing low and only slowly increasing costs; for the higher temperatures it becomes flatter, showing rapidly increasing costs; finally, a maximum temperature is reached beyond which it is not possible to go, as the temperature would diminish again. This latter point is reached when the air-blast is so great that the flue gases carry off the heat as fast as it can be generated by the fuel. When this point is exceeded, the fire goes out, as is illustrated by the blowing out of a candle-flame; the volume of air then is so great that the flame can no longer heat it, hence the wick chills and the flame goes out. These maximum temperatures are approached in steel furnaces. The chief feature of this curve is that at these high temperatures the cost increases very rapidly; regenerators, for instance, will increase the temperature, but at considerable cost.

The corresponding curve for the electric furnaces is approximately a straight inclined line as shown, which intersects the other. This

means that the cost increases roughly proportionately with the temperature, and there is no definite maximum within practical limits. Hence for the lower temperatures the combustion heat is generally the cheaper; at a certain higher temperature they are equal; above that the electric heat is the cheaper, and for very high temperatures it is the only available means. For temperatures above this intersection point the cheapest method, therefore, is to use a combination of both, fuel being used for the lower temperature heat, and electric energy for the higher. This is what is common practice now in the

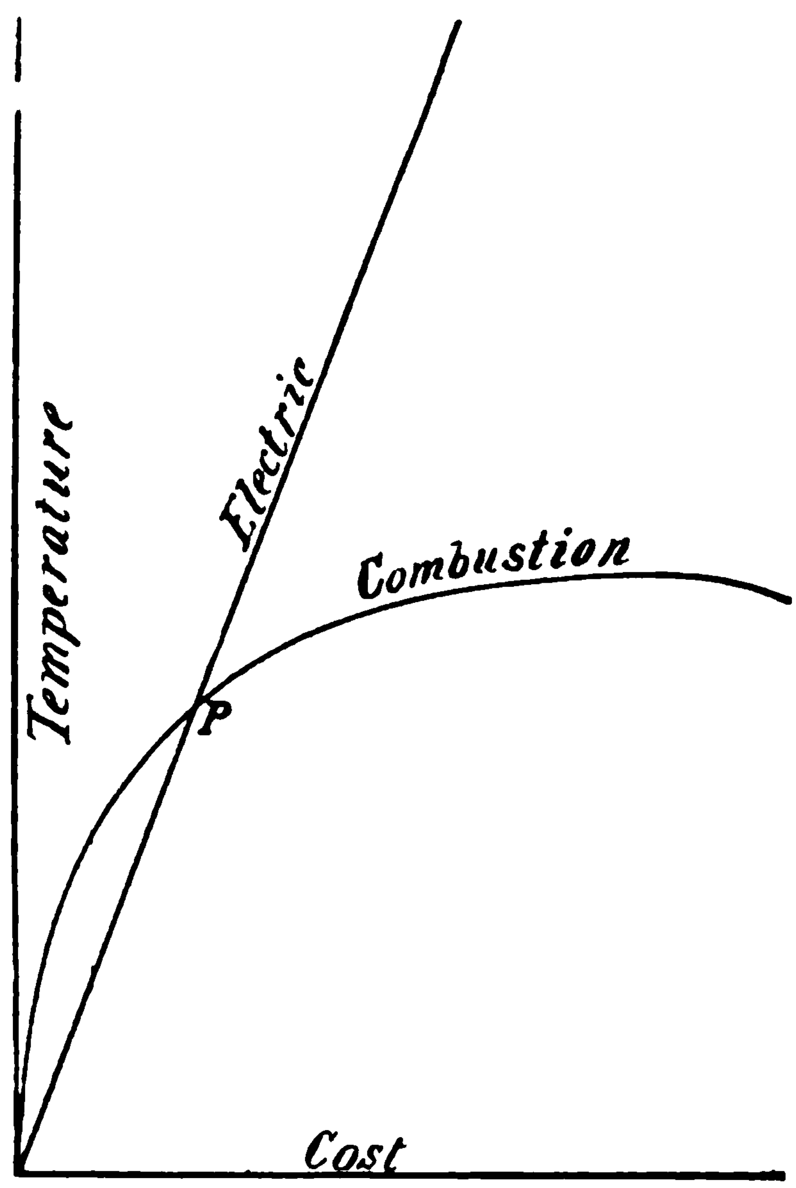



FIG. 1.

electric steel industry, in which the cold metal is first melted by means of fuel heat and then transferred to the electric furnace for treatment at the higher temperatures. These curves will, of course, vary greatly with the cost of coal and water-power; they are given here to show only very general characteristics.

Other characteristics of the electric furnaces are that there are no chimney gases with their attending losses, including those carried away by the useless nitrogen; there is no lighting of fires necessary; the generation of heat is accomplished very quickly; the atmosphere

is neutral; the control of the heat is far more simple and perfect, etc.

As was stated above, the thermal efficiency of an electric furnace is the most important feature from the standpoint of the designing engineer, as it is the cost of the energy which is generally the criterion as to whether "it will pay" to use the electric furnace; an increase in the thermal efficiency means a decreased cost of this expensive form of energy. Hence after the metallurgist has established the necessary conditions as to temperature, quantity of heat, interior capacity, etc., it is for the engineer so to construct the furnace that the heat losses will become as low as practicable.

As all electric furnaces are or should be enclosed, there are two sources of loss of heat—the heat which flows out through the walls, and that which flows out through the electrodes. Until a few years ago our knowledge of the data, laws, and rules of construction concerning these two losses of heat were so crude, inadequate, unreliable, and unsatisfactory that the writer made analytic researches to determine the underlying principles and laws governing correct design, the results of which showed that in part our former practice was positively wrong, and had led us away from, instead of toward, the correct design. These researches have been fully described and published elsewhere by the writer; the results may be briefly summarized as follows:

The general law for the quantitative determination of the flow of heat through a body has been given above. The difficulties in applying it to the heat leakage through furnace walls lie in the lack of proper units and physical constants of materials, and in the fact that with thick walls, as are used in furnaces, the cross-section of the path of the flow of heat increases greatly from the inside surface to the outside. Suitable units have now been proposed (see above); the physical constants are still badly needed, but some fairly good ones exist and others will probably be forthcoming.

Concerning the flaring cross-section of the path of the flow, the usual rule has been to take the arithmetic mean between the inside and outside. Believing this to be unreliable, the writer some years ago determined the strictly correct formulas for such varying cross-sections* and found that, while the old rule was approximately correct for very thin walls, it was very greatly in error (100 per cent. and more)

* "Heat Conductances through Walls of Furnace," Trans. Amer. Electrochem. Soc., vol. xiv, 1908, p. 215.

The dotted curves show the results when the usual formula is used, while the solid ones are those for the correct formulas. It will be seen that not only is their divergence very great for the greater thicknesses, but the dotted lines actually have a minimum point, after which they rise again, which of course would be absurd, as it would mean that a further increase of wall thickness would actually increase the losses again. This shows the danger of using approximate formulas. The curves for the cylindrical forms are not directly comparable with the others, as they are for a cylinder of unit length, and must therefore be multiplied by the length, and the heat losses through the ends must be added.

A further study of these results, as indicated by diagrams in the original paper, shows how very important it is, when this loss is important, to reduce the inside of the furnace as much as possible to hold the required charge; that is, one should not waste any space in the interior by making the inside any larger than necessary, because the wall thickness, to keep the loss down to the same amount, increases very rapidly as the inside becomes larger. Another important result is that for the same percentage loss in small and large furnaces the wall thicknesses become enormously larger for the smaller ones; hence, as far as these losses are concerned, it is far more economical to use one furnace of the total capacity than to use several smaller ones which are together equal to the large one. For the same wall thickness, relatively to the inside dimensions, the losses per unit capacity—that is, per pound of metal melted—diminish rapidly as the furnaces become larger. Further results and details are given in the original paper.

The loss of heat through and in the electrodes is a far more complicated matter. These electrodes, which extend from the cold outside to the hot inside, generally have to carry very large currents; they ought for this reason to be made of a good electric conductor, large in section and short, in order not to waste energy due to their electric resistance. On the other hand, when thus made they carry off large quantities of heat from the interior of the furnace, because a good electric conductor is generally also a good heat conductor. When they lead off much heat, it chills the product in the interior of the furnace, thereby diminishing the available interior space,—that is, the capacity,—and the heat efficiency becomes poor. The conditions for leading off as little heat as possible are directly opposite to those mentioned above for diminishing the electric resistance losses;

open pipe is connected. Let the required conditions be that this pipe cannot be closed, yet no water shall flow out of the tank through the pipe. This can be accomplished by forcing water into this pipe, from other sources, at such a rate that the pressure at the tank end of the pipe will be equal to that in the tank. A static pressure is thus produced dynamically.

Former practice had led to making the electrodes larger and larger, to keep them cool; this made them more and more costly and more difficult to handle. The above analysis shows that they should have been made smaller instead, so as to stop the loss of heat from the furnace product where it is wanted; the heat generated in the electrode costs less than that in the furnace, as it has to be transmitted (as electric energy) over a shorter distance. Such reductions in the size

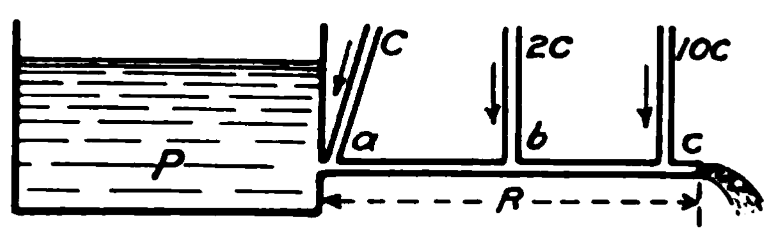



FIG. 3.

of electrodes result in large annual savings not only of power, but of electrode materials also. And it increases the valuable available space in the furnace by not chilling a more or less large part of the product.

This analysis brought to light another fallacy. Formerly it was claimed very positively by certain parties that graphite was a worse material to use than carbon, on account of its much higher heat conductivity; it was claimed to "chill the product too much," and therefore very wasteful of energy. The above analysis showed that this too was an error, as this chilling may be entirely prevented by proper proportioning; and when thus proportioned graphite is even less wasteful than carbon.

The explanation of this is that the minimum losses and the best proportions do not depend on either the electric or the thermal conductivities alone, but on certain relations between them. Neither property alone is a criterion. This brought out the surprising fact that the best electrode materials, from the standpoint of the least possible electrode losses, and the smallest amount of electrode material, were the metals; and of these, copper, the best of all heat conductors, was decidedly the most economical. Hence electrodes should be made of metals whenever possible, if economy of power and

PAPER NO. 1103.

# THE SUPERSTRUCTURE OF THE PASSYUNK BRIDGE.

HENRY H. QUIMBY

(Active Member.)

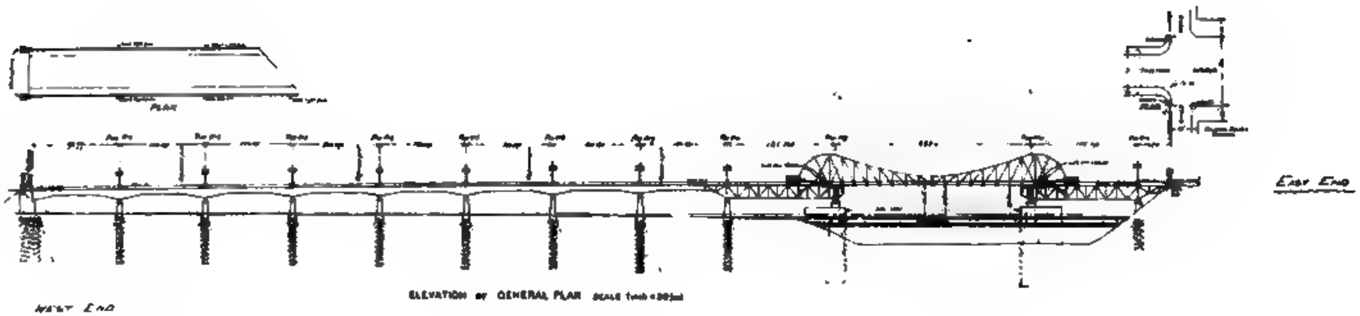
*Read February 18, 1911.*

AT the meeting of the Club on September 18, 1909, a paper was presented describing the substructure work of the Passyunk Bridge, which crosses the Schuylkill River on the line of Passyunk Avenue at Point Breeze, Philadelphia. The superstructure has since been erected, and is now ready for the paving, which is also to be done under the present contract.

The bridge is 1323 feet long, with a 38 feet driveway and two 9 feet 6 inch sidewalks, making a total width of 57 feet. The driveway is to be paved with asphalt, except on the bascule span, where it will be of creosoted wood plank, and the sidewalks and curbs will be granolithic, except on the bascule span, where they will be of uncreosoted yellow pine..

The main channel span, which gives a clear waterway of 200 feet and a clear height throughout this width of about 35 feet above high-water line, is a through-truss trunnion bascule of two leaves. The approach spans at both sides are deck construction. The flank spans, immediately adjoining the channel span, are each carried by two lattice riveted trusses of 126 feet, center to center of piers. The eight approach spans on the west side of the river are 100 feet each, with three lines of plate-girders in alternate fixed or anchor spans, and cantilevered with suspended spans. The extreme east approach span is 47 feet, consisting of 25 feet of cantilever from the lattice span and 22 feet of I-beam construction with concrete floor arches.

The foundations of the west abutment and all the piers except the channel piers are wooden piles capped with concrete. The two channel piers were carried to bed-rock by compressed-air caissons of wood, the east pier No. 10 reaching a depth of 89 feet below city datum, which is 2.25 feet above mean high water. The west channel pier No. 9 found rock at a general elevation of about –85. These two piers, therefore, are of solid concrete, approximately 100 feet





Passyunk Bridge—General Plan.

The live loads for which the bridge was designed are a general live load of 90 pounds per square foot over the whole area, sidewalks and driveway, or 110 pounds per square foot on individual panels of the sidewalk, and concentrated loads in the driveway of two lines of street railway cars weighing 36 tons each on wheel base of 25 feet, and occupying each a width of 10 feet, or a truck weighing 40 tons on two axles 20 feet apart at any point of the driveway.

The unit stresses in the flanges of the plate girders of the approach and in the chords and web members of the latticed flank spans were the standard specifications for bridges of the Bureau of Surveys, City of Philadelphia, Mr. George S. Webster, Chief Engineer.

Tension, 10,000 $\left(1+\frac{\text{min}}{\text{max}}\right)$, not exceeding 15,000 pounds per sq. in.

Compression $\left(14{,}000-40\,\frac{l}{r}\right)\left(1+\frac{\text{min}}{\text{max}}\right)$.

The unit stresses in the trusses of the bascule leaves were arbitrarily adjusted to reduce the tension in members over the reaction points to 12,000 pounds maximum, increasing by 500 pounds per sq. in. for each panel to 15,000 pounds at the extreme end, on the theory that the effect of impact will be greatest at the point of greatest rigidity, and will decrease as the flexibility of the truss increases. The most considerable impact will be that possible to be produced by careless operation—say, in closing the leaves down too suddenly. For this there is, besides the provision of pneumatic buffers to absorb such a shock, the fact of the dead-load stresses being only from 40 to 45 per cent. of the maximum stresses for which the sections are proportioned, giving really very conservative strains.

The plate girders of the west approach were originally designed so that they could be shipped in 50 foot lengths and erected upon two bents of falsework in each span, and riveted up in position. The cantilevers of these spans are 25 feet long, leaving the suspended spans 50 feet long. The girders, however, by arrangement between the shops and the erectors, were riveted up at the shops in lengths from 50 feet to 112 feet 6 inches, bringing the field splices always 12 feet 6 inches from the center pier, except in the case of the joints of the suspended spans and cantilever arms. This arrangement permitted the erection of all the spans, except the flank spans, by means of a traveler, with a boom sufficiently long to reach over more than half of one span. The derrick used had a steel boom 85 feet long, competent to handle 40 tons in its horizontal position. The heaviest girder handled weighed 25 tons.

The anchor ends of the trusses are segmental, with a radius of 35 feet, and contain $5\frac{1}{2}$ inch pins, 11 inches on centers, which constitute the rack by means of which the leaf is operated. These anchor ends pass down through a slot in the floor 24 inches wide, which is closed by a horizontal plate flush with the sidewalk when the leaves are closed. It is, of course, impossible to have any transverse bracing between these segments, and the spokes which support the segments, therefore, depend upon their riveting to the large plate gussets which are riveted to the cast-steel hubs on the trunnion. The bracing thus provided is found to be ample, no tendency being shown for any wabbling of the segments under operation. The main driving pinions are 30 inches pitch diameter of cast steel, with 11 inch pitch of teeth. Each pair of pinions operating a leaf is connected together by a 9 inch shaft, which is driven by a train of steel gears, the power being furnished by two 75 horsepower motors connected to the same countershaft. Thus, if one motor of the pair should get out of order, the other motor will be sufficient to operate the leaf, except in case of a very high wind. And, if a break should occur in either of the trains of gears, the other train of gears will operate the leaf through the shaft that connects the main pinions.

A duplicate system of control of motors has been provided, so that the two leaves can be operated from either side of the river. It is intended that, although the two leaves are independent of each other, they shall be operated by one man, the meshing together of the two leaves at the middle being such that it is desirable that the same mind shall control the two leaves.

This meshing of the leaves together at the middle is intended as a safety device to compel careful operation, as well as to constitute a lock which will insure the two leaves deflecting together under load, it being impossible for either leaf to deflect without carrying the other down with it. This meshing consists of pockets and seats so proportioned that the bottom chord of the east leaf bears in a pocket on the west leaf, and the top chord of the east leaf enters under a projection of the top chord of the west leaf.

The method of operation thus required consists in lowering the west leaf in advance of the east leaf to a point within about 5 feet of the bearing when the east leaf is brought down, engaging the west leaf on the bottom chord, and pulling the two leaves down together by the machinery of the east leaf. Thus, if the east leaf should be lowered ahead of the west leaf, it would have to be raised again in order to

it approaches the side of the pier as the leaf reaches the open position. The top of the box was determined by the clearance under the stringers when the leaf is closed down, the idea being to get the counterweight as deep as possible. The depth then determined the width, the aim being to get the box as narrow as possible, in order that the center of gravity of the counterweight should be as far from the trunnion and as much below the level of the trunnion as possible. The greater the radius of action of the counterweight, the more effective it is, and the lighter it needs to be.

E. M. Nichols.—Does the counterweight go into the water?

Mr. Quimby.—No; the extreme edge of the segment will just clear mean high water. Of course, we are liable to have freshets which will reach the rack segment, but an occasional immersion will do no harm. It is only rarely necessary to open the bridge to its full height, and therefore on such special occasions the immersion can probably be avoided. The pile fenders around the piers are extended back of the piers sufficiently far to fence off a yard into which the counterweight descends, to prevent any river-craft from getting in under the descending counterweight.

Mr. Easby.—Do you get equal moments on both sides of the trunnion for all positions of the bridge from dead load?

Mr. Quimby.—Yes; the center of gravity of the whole rotating mass—trusses, floor, and counterweight—is in the trunnion, a little below the center of it. Of course, you cannot counterweight against wind nor against live load. The machinery must hold the leaf against the wind, which may act in either direction. We have figured on a wind pressure of 16 pounds per square foot on the exposed surface of the flooring when the bridge is up, and designed all the machinery for the resulting forces, which amount to 90 tons on the rack of one leaf—45 tons per truss heel.

W. H. Ford.—How far does it project over the channel line?

Mr. Quimby.—When the leaf is fully raised, we have a full way clearance of 200 feet to a point 135 feet above the high-water line. Above that the floor of the bridge extends at an angle of 11° for perhaps two panels—the projection over the clearance line of the fender will be over two feet.

Mr. Ford.—Do you not consider it a serious objection to have that interlocking device at the middle of the two leaves, on account of it being successfully operated only when the operator acts carefully? Is there no danger of smashing something up there?

Mr. Quimby.—There is slight danger of smashing anything. If he puts his leaf down too far, he simply has to raise it again to connect.

Mr. Ford.—If he does not do it right, he is liable to get in trouble; can he not jam?

Mr. Quimby.—No, he cannot jam in the sense of wedging in tight, but within a small range—about eight inches—he can strike and bruise the truss ends.

Mr. Nichols.—Where does the man stand who operates those leaves?

Mr. Quimby.—In the bay-window of either one of the two operating cabins or houses where the controllers are placed. He can operate both leaves from either side of the river. Each operating cabin has two controllers—one controller for each leaf.

J. C. Trautwine, Jr.—How is the control carried across the river?

Mr. Quimby.—By submarine cable, with power from the P. R. T. Co.

Mr. Trautwine.—What time is required for raising one of those leaves?

Mr. Quimby.—About three-quarters of a minute. The total weight moved with each leaf is about 800 tons, and it uses 25 or 30 horsepower.

Mr. Easby.—What kind of paint are you going to use to protect that framing?

Mr. Quimby.—The priming coat is red lead, and the finishing two coats are of white lead tinted different shades.

PAPER NO. 1104.

# THE SANITARY PROBLEMS OF THE CATSKILL AQUEDUCT.

DR. DAVID S. FLYNN.
(Visitor.)

*Read September 16, 1911.*

THE engineering features of the Catskill aqueduct consist of the erection of a large dam for impounding the water-supply, the construction of about 90 miles of aqueduct, a large distributing or equalizing reservoir on high land in Westchester County, New York, and another equalizing reservoir at the beginning of the main distribution system, which runs beneath the city's streets. Contracts for all this work are under way, numbering about thirty, with about ninety camps and employing about twenty thousand men.

The work is under the charge of Mr. J. Waldo Smith as chief engineer of the Board of Water-supply. The consulting sanitary experts of the Board are Mr. A. J. Provost, Jr., C. E., and Dr. Herbert D. Pease, who assigned the author to supervise the field conditions.

The principal sanitary problems relate to housing the workmen and regulating their modes of living by precautions not heretofore fully observed on similar works. Only a very small percentage of the workmen come from the territory through which the work passes, and most of them are foreigners, such as Italians, Slavs, and Poles. There are also a considerable number of negroes, especially on the tunnel jobs.

Laborers of these classes are invariably careless in their habits, settling down in contentment in dirty shacks of their own construction, denying themselves regular and proper nourishment, and oftentimes introducing dangerous conditions to an established community.

With the beginning of the Catskill aqueduct, it became evident that a comprehensive sanitary regulation of the camps and of the men was necessary.

In the first place, the communities through which the work passed should be protected against communicable diseases.

Second, all public and private drinking-water supplies, whose watersheds came within the sphere of action of the aqueduct work, must be protected against pollution.

of dipping. Ponds, lakes, brooks, and rivers are so subject to contamination that their use can be permitted only when the water is effectively filtered.

Above all things, one supply should be chosen and all others forbidden, and periodic examinations of the supply should be made.

*Food-supplies.*—The first concern is the milk-supply. In the small camps oftentimes no fresh milk is used. But in the larger camps, where there are children and families, it has been found necessary to supervise the farms from which the milk comes, and to advise as to the care of the milk during transportation and delivery to the consumer. The opportunities of contaminating milk with pathogenic bacteria are many. The pail in which it is collected, the person of the milker, the water in which it is cooled, or the water which is added to swell the quantities, are but a few of the common sources by which milk becomes polluted. Where the enforcing of regulations failed and tests showed that milk was not as good as it should have been, pasteurized milk was recommended, and in the one camp where a fair test was made there were no deaths from summer complaints, when during the previous summer there had been ten deaths.

The source of green vegetables, which may be fertilized with human excreta or grown in contact with sewage or polluted water, had to be examined as far as possible, and positive rules made that vegetables be screened when exposed for sale.

Some of the camps have bakeries for supplying the peculiar Italian bread, and these are generally kept scrupulously clean, but here again screening is necessary.

Whatever work is done along these lines is impossible without the coöperation of the contractor, and it is a pleasure to testify that the contractors on the aqueduct assisted in every way to protect food-supplies.

*Waste Disposal.*—This includes refuse of animal and vegetable origin, which may serve as breeding-spots for flies, and also may contain pathogenic organisms dangerous to the camps when transferred to human hosts by flies; also house dust and rubbish, which may contain particularly the contagion of tuberculosis, diphtheria, and pneumonia.

The waste products may be classified as follows:

1. Human excreta and urine.
2. Surgical and medical dressings, bandages, discharges, etc.
3. Stable manure.

closely under the seats and easily removable through a hinged door in the back of the closet, in conjunction with masonry grate bar furnaces, have been found cheaper and more satisfactory. The general practice now is to build the furnace in two or three sections, and in it dispose of all the refuse of the camp.

In twenty-nine months of supervision of the Catskill aqueduct there were but fourteen cases of typhoid fever, and this very low number is owing to the very general practice of incinerating human wastes, the rubbish and garbage, stable manure, in many camps, and to general screening.

The method adopted to dispose of *liquid wastes*, such as kitchen slops and the waste from laundries and wash-houses, is that of collection by drains, which lead through a grease trap into a settling basin and duplicate sand filters. The effluent then may be delivered to any stream not used as a potable supply. Should it be used as a drinking supply, further treatment is used, generally that of dosing with hyperchlorite of calcium, by means of an automatic apparatus.

*Ventilation, Heating, and Lighting.*—Human beings, after all, are machines, and, like them, will not reach their highest point of efficiency unless certain precautions are taken in regard to their repair and upkeep. The upkeep of the human body requires a definite amount of breathing space, a fixed supply of fresh air, added at a regular rate, a certain amount of direct solar light, and adequate means of artificial heating and lighting.

The minimum air-space per occupant was fixed at 400 cubic feet, and it was specified that some method of ventilation should be supplied besides that given by doors and windows. It is generally accomplished by louvers on the ridge of the shacks. This ventilator has a free horizontal area of about ¼ foot per occupant. The minimum of window-space was set at 3 square feet per occupant, and these windows must be placed on all sides of the buildings.

*Medical Supervision.*—The Board of Water-supply contracts all specify that one or more qualified medical practitioners shall be employed, and on all the watersheds the board pays the contractor to build a man-proof fence, which will keep the men in certain bounds and which tends to keep down promiscuous committing of nuisances. The important step that has been taken forward, on the Catskill aqueduct, is the recognition of preventive medicine. Contractors' physicians have as a duty the examination of every applicant for work, so that men suffering from evident disease may be at once rejected. Next the laborer is vaccinated and given a certificate,

Supplies of vaccine, diphtheria and tetanus antitoxins, and anti-streptococcic serum, the Pasteur treatment, and typhoid vaccine are furnished to the contractor free of charge by the Department of Health of New York city. In suspected cases of tuberculosis, diphtheria, typhoid, dysentery, etc., samples of sputum, membrane, blood, or feces, as the case may be, are forwarded for laboratory examination, and reports wired to aid the physicians in making certain diagnoses.

With about four thousand men working for over two years within the confines of the Croton watershed, there has been but one case of typhoid. This case was positively recognized by the Widal reaction within three hours, and the patient was moved to a hospital outside the watershed within twenty hours after the blood was drawn by the physician.

Ten important watersheds are touched on by the aqueduct, but by far the most important of these is the Croton shed, from which New York's present supply comes. This shed is occupied by about 10 miles of the line of work, and contains five camps. The camp sites have been leased or purchased by the contractors after most careful consideration was given as to their suitability. Direct compensation is given by the city, under the contracts, for installation and maintenance of the camps, and practically all the working force is obliged to live in the camps. The exceptions from this rule are a few of the skilled laborers owning their own homes, the location of which is shown on an official plan, and the sanitary condition of which must be reported weekly by the contractor's physician. Nothing but incinerating closets have been permitted, and the camp garbage and rubbish is likewise burned. Each room has to be swept daily by its occupant, and the sweepings are gathered from the hallway by a sanitary gang, by which the collections are carried to the incinerating furnace. Each contract has a physician who must stay within a mile of the camp at all times, and is held personally responsible for the sanitary condition of the contract. The camp is surrounded by a man-proof fence and must be illuminated with electric lights from sunset to sunrise.

Surrounding each camp and just outside of the man-proof fence are collecting ditches for conveying all rain-water and surface wash to the sanitary works. These ditches are sufficient to care for a run-off of 4¾ inches in one hour. Sedimentation and storage basins have capacity for run-off, in excess of filtration rate, amounting from 60 to 80 per cent. of Talbot's curve for twenty-four hours.

[illegible] effective size, 0.25 to 0.35 mm. [illegible] million gallons per acre per [illegible]

[illegible] for treating filtrate [illegible] available chlorin, at rate [illegible]

[illegible] fifteen minutes' retention at maximum [illegible]

There are no [illegible] camps. Liquid wastes, [illegible] which leads to a [illegible] from maximum [illegible] daily. The effluent from this [illegible] surface of one of the [illegible] provided with a [illegible] The filtrate then passes through the [illegible] before reaching a [illegible] at shafts and [illegible] are provided with [illegible] of which are brought to the [illegible]

[illegible] greater attention to the [illegible] The efficiency of the working force is in[illegible] made in its living conditions.

[illegible] the Board's statistics as to health would [illegible] the well-kept camps. From [illegible] that some of the contractors have [illegible] for a number of years, and these men [illegible] the ones who had clean shacks, and [illegible] It is this class of men which forms the [illegible] believed that this class of faithful [illegible] would be formed in large numbers [illegible] lines set forth in this paper.

## DISCUSSION.

[illegible] —The [illegible] made is obviously in accord with the thoughts of all [illegible] The paper is progressive, and takes a position with which every intelligent person [illegible] It is valuable in bringing to our notice in [illegible]ful accomplishments of sanitation in accordance with up-to-[illegible] There has been a struggle against these methods, and we are [illegible] the full effects of men working in masses, and can only

conclude that there must be an artificial system of sanitation in which the rights of the individual must give way to the rights of the community, and a restriction be put upon what might be called "spontaneous behavior."

I have been interested all my life in questions of sanitary engineering, beginning forty years ago to study the subjects of water-supply and sewage-disposal, and I have to some extent a knowledge of how this work has grown and how difficult it has been to make progress. Forty years ago it was difficult to convince anybody engaged in engineering or in public affairs of the necessity of strict methods. I can recollect when even stables were supposed to be "healthy," and I know that the getting rid of such ideas has been a very slow growth. It has been necessary, as the writer of the paper said, to use the argument of profit as well as the argument of decency in enforcing the rules which have been laid down for the safeguarding of health and the elimination of disease-fostering sources. We have yet to show people that it will pay to do right. Such demonstrations as these will go far toward holding up the hands of those who are in charge of these works and urging still more radical reforms.

With regard to typhoid fever, it is now thought that a great deal of it is due to distribution by contagion, and not only to drinking-water. In spite of all precautions typhoid may be introduced by some one infected with the disease, and one might think the precautions taken are unnecessary; but the low figures do not, under these conditions, need any further demonstration of their value.

Now, it may perhaps seem a little like levity to say so, but I could not help wondering, when the "man-proof fence" was mentioned, whether a "woman-proof fence" had been considered also. How about prostitution? It will be more difficult to control that, perhaps, than any other cause of disease; but it will come up. As other conditions are rendered less important by the elimination of their results, the question of venereal disease will come to the fore.

We owe a vote of thanks to the author of the paper; it illustrates practical conditions and is a very important step in civil engineering operations.

H. C. Berry.—I would like to ask about the typhoid vaccine given to the soldiers the other day for typhoid fever?

Dr. Leffmann.—The treatment of typhoid by toxins is new, and I do not think we yet have data sufficient to give a positive opinion as to their value, but it is possible in certain cases, where they are taken in time, to arrest the disease. For instance, if one can get the ordinary vaccination started so that it will be well on its way before the symptoms of smallpox appear, the vaccination will modify the smallpox. Unfortunately, these diseases have different periods of incubation, and it is some time before people really know what is the matter with them, although they may have been ailing for some time previously. Every now and then occur cases of "walking typhoid."

Mr. Robert Schmitz.—I think the work done on this aqueduct as described by Dr. Flynn is highly commendable, and is a long step in the right direction, and shows improvement in the methods of doing such work. I trust these methods will be followed voluntarily at other large works, and I hope that in time these methods, or similar methods, or perhaps even improved ones, will be prescribed by law.

introducing more efficient machinery, and organizing and regulating labor. By these means he enabled Pencoyd to meet the competition of Pittsburg, and made it one of the largest and most efficient works in the eastern section of the country. The owners, A. and P. Roberts & Co., entered heartily into the spirit of Mr. Christie's efforts, and called to his aid experts in the several new departments established. By his wide knowledge of mechanical engineering, universally recognized integrity, and engaging personality, Mr. Christie secured and held the respect and co-operation of these special assistants.

During all these years he took an active part in the promotion of engineering science, in public affairs, and in questions of social reform. The catholicity of his literary tastes carried him beyond the narrow limits that so often restrict the expert, and to this fact is largely due the charm that his friends and acquaintances found in his companionship.

In 1884 he published "Experiments on the Strength of Wrought Iron Struts," based on tests made by him at Pencoyd. This paper, one of the classics of the profession, won for him the Norman medal of the American Society of Civil Engineers.

His interest in public affairs led to his being occasionally chosen for public office on some of those rare occasions when an American community, having wearied of corruption, seeks an honest man. About 1870 Mr. Christie was Mayor of Phillipsburg, N. J., and from 1907 to 1910 was Select Councilman from the 21st ward of Philadelphia, being one of the few members of that body chosen on an outspoken reform platform. In this ward, of which he was a resident for many years, he took active part in local educational movements and was also interested in material development, being a director in the local trolley line.

While at Phillipsburg, Mr. Christie was superintendent of the Phillipsburg Manufacturing Co., builders of iron bridges, serving with Mr. Alfred P. Boller, chief engineer. Here he and Mr. Boller made important studies of the design of rolled beams, in which work they were assisted by Professor W. H. Burr. Recently, Mr. Christie built, at Ambridge, Pa., the works of the American Bridge Company, the greatest bridge plant in the world.

Mr. Christie made numerous contributions to general and scientific literature. In Philadelphia his activity in scientific work was principally in association with The Engineers' Club and the Franklin Institute. For many years he was a member of the Board of Man-

# ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS.

ADJOURNED MEETING, July 20, 1911.—Present: President Christie, Vice-Presidents Hewitt and Plack, Directors Swaab, Halstead, Develin, Gilpin, and Vogleson, the Secretary, and the Treasurer.

The Secretary presented a report of the financial condition of the Club, which showed a net gain of $626.44 for the first half of the year.

Upon motion of the Secretary the sum of $105.95 was appropriated to the Entertainment Committee to cover deficits in the entertainments during the past season.

A list of members delinquent in dues and house charges was read, and it was ordered that these delinquents be carried upon the roll until the regular meeting of the Board in September, at which time the Treasurer was instructed to report upon each individual case.

The following resignations were read and accepted: I. W. Hubbard, John E. Allen, Chas. S. Redding, J. L. Beaver, B. G. Love, W. D. Gernet, M. R. Pugh, H. R. Goshorn, H. L. Benner, E. B. Smith, R. E. B. Sharp, and Thos. A. Edison.

The Secretary announced the deaths of Mr. Francis Schumann and Mr. Howard Wood.

Upon motion, Mr. C. H. Ott was reinstated to active membership.

It was ordered that the Engineers' Club apply for associate membership in the National Fire Protection Association, and five dollars was appropriated to meet the payment of dues of this organization.

SPECIAL MEETING, August 28, 1911.—Present: Vice-Presidents Hess, Hewitt, and Plack, Directors Medus, Kerrick, Worley, Cooke, and Gilpin, and the Secretary. This meeting was called on account of the sudden death of President Christie, on August 24th. Vice-President Charles Hewitt was appointed to represent the Club at Mr. Christie's funeral.

Messrs. Henry Leffmann, John C. Trautwine, Jr., and Wm. R. Webster were appointed a committee to prepare a memorial, and the Secretary was instructed to prepare resolutions to present at the next regular meeting of the Board.

The next regular Board meeting was, upon motion, advanced from the 14th to the 5th of September.

REGULAR MEETING, September 5, 1911.—Present: Vice-Presidents Hess and Plack, Directors Hutchinson, Swaab, Halstead, Develin, and Vogleson, and the Secretary.

The matter of the execution of a memorial or resolution of the late President, James Christie, was discussed, and ordered laid over until the following meeting of the Board.

The committee on the regulation of smoking in the meeting-room stated that it would make a report at the next meeting of the Board.

The Treasurer, who was to report at this meeting on the delinquent accounts,

wrote, stating that he would be unable to attend this meeting, and would report at the meeting following.

The resignation of Mr. S. J. Dickey was read and accepted as of July 1, 1911.

Correspondence from Mr. Carl Hering, relative to certain matters in the house, was tabled until the next meeting of the Board, so that the chairman of the House Committee could be present during the discussion.

A letter from the Third Conservation Congress, requesting the appointment of delegates, was ordered to be read at the following regular meeting of the Club.

The work of the Committee on Standards was discussed, but no formal action was taken.

Mr. Henry Hess was elected President of the Club to fill the vacancy caused by the death of Mr. Christie. Mr. Edward S. Hutchinson was elected first Vice-President in Mr. Hess's place, and Mr. Benjamin A. Haldeman was elected Director in Mr. Hutchinson's place, all elections to take effect immediately, and for terms to expire in February, 1912.

It was ordered that the regular meetings of the Board for the coming winter be held on the third Wednesday of each month.